An Evaluation of CGIAR Centers' Impact Assessment Work on Livestock-Related Research (1990 – 2014)

CGIAR | Independent Science and Partnership Council

Standing Panel on Impact Assessment
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Acronyms

ASTI	Agricultural Science and Technology Indicators
BBM	Broad Bed Maker
BCR	Benefit Cost Ratio
CCER	Center Commissioned External Review
CFA	Communauté Financière Africaine
CGE	Computable General Equilibrium
CGI	Crop Genetic Improvement
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CRP	CGIAR Research Programme
DALY	Disability-Adjusted Life Years
DFID	Department for International Development
DGs	Directors-General
EcoZD	Ecosystem Approaches to the Better Management of Zoonotic Emerging Infectious Diseases in Southeast Asia
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
epIA	*ex-post* Impact Assessment
EPMR	External Programme and Management Review
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IA	Impact Assessment
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRAF	World Agroforestry Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDE	Integrated Development Environment
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
ILRAD	International Laboratory for Research on Animal Diseases
ILRI	International Livestock Research Institute
INRM	Integrated Natural Resources Management
IPG	International Public Good
IPGRI	International Plant Genetic Resources Institute (Bioversity)
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
ISPC	Independent Science and Partnership Council
NBER	National Bureau of Economic Research
NPV	Net Present Value
NRM	Natural Resource Management
OM	Outcome Mapping
PSM	Propensity Score Matching
R&D	Research and Development
R4D	Research for Development
RCT	Randomized Control Trial

SCUAF	Soil Change Under Agro-Forestry
SDGs	UN Sustainable Development Goals
SDP	Smallholder Dairy Project
SIAC	Strengthening Impact Assessment in the CGIAR
SLO	System Level Outcomes
SLP	System-wide Livestock Programme
SPIA	Standing Panel on Impact Assessment
SRF	Strategy and Results Framework
TORs	Terms of Reference

Acknowledgements and Authors' Disclosure

This study was not only commissioned by SPIA, but also benefitted from the continuous assistance from both the secretariat (T. Kelley) and the chair of SPIA (D. Gollin); this support is gratefully acknowledged. Given the size of the desk study, only limited background search could be performed by the consultants – the study therefore relied almost exclusively on the inputs provided by the Center DGs and their impact assessment (IA) focal points addressed. This input, where provided, is highly appreciated. In particular, the review team wishes to single out the efforts undertaken by the DG of ILRI (J. Smith), the Director of the CRP on Livestock and Fish (T. Randolph), and their staff to identify relevant impact assessment reports of livestock-related research at ILRI and across the CGIAR.

It is important to note that both consultants have long-standing linkages and relationships to some of the Centers and Programmes reported on in this study:

S. Jutzi was an ILCA staff member in the 1980s, inter alia as head of the Highlands Programme, as leader of the Joint ILCA/ICRISAT Vertisol Management Project [with the BBM technology reported on in this study], and as coordinator of the Forage Resources and Animal Traction Thrusts. In the 1990s he was a member of CIAT's Board of Trustees (chair of Programme Committee) and participated in CGIAR commissioned external reviews at IPGRI, IITA, CIAT, and ICRAF; in 1999 he was panel chair for the first ILRI EPMR. As Director of FAO's Animal Production and Health Division (1999-2011), he commissioned the study on the impact of rinderpest eradication referred to in this report.

K. Rich was previously an agricultural economist with ILRI during 2006-2008 in its then Markets theme, working on issues of animal health economics and value chain analysis. He contributed technical inputs on the multimarket model used in the *ex-post* impact assessment on ILRI's SDP in 2008. Since 2008, Dr. Rich has worked periodically as a consultant and collaborator to ILRI in similar capacities. While at the Norwegian Institute of International Affairs during 2010-2014, he was a joint-appointee with ILRI as part of ILRI's CRP2. However, his work on the rinderpest *epIA* included in this study was funded separately by FAO and not as part of his research work with ILRI.

Foreword

Over the past several years, one of the major areas of work for SPIA has been an effort to advance the evidence base and for impact assessments in previously under-evaluated areas of CGIAR research. SPIA's goal has been to expand impact assessment beyond the narrow domain of crop germplasm improvement where most ex post impact assessments (epIAs) have traditionally concentrated. Accordingly, SPIA has sought to assess the evidence for impact in key areas of CGIAR research effort: irrigation and water management, livestock management, policy-oriented research, natural resource management, agro-forestry, and in-situ conservation of biodiversity.

This review of the impact assessment work on livestock and livestock-related research in the CGIAR is the second scoping study commissioned by SPIA to assess the impact evidence across these under-evaluated areas within the CGIAR portfolio. (A previous study explored the impact evidence for irrigation and water management research.) It is critical to have these assessments. EpIAs inform donors and other stakeholders about the multi-dimensional impacts of the research (or lack thereof). But they also, when considered with information on research investments, tell us something about research efficiency and effectiveness. For this reason, understanding the extent and quality of evidence is critical. For this review, SPIA was fortunate to be able to engage two highly qualified consultants with long and broad experience in livestock research and development; both are familiar with the CGIAR but are based outside the system and can bring independent and objective perspectives: Samuel Jutzi, agronomist/agricultural economist and Karl Rich, an agricultural economist. This is the first system-wide review of the evidence of impact from livestock research in the CGIAR, and SPIA would like to put on record its appreciation for the extensive effort and thorough evaluation carried out by the review team. After the original report was submitted, SPIA carried out its own (lengthy and delayed) review of the report; the current version reflects this review process and the responses of the authors.

Animal agriculture is certain to be a key component of global food systems over the decades ahead. The increased demand for livestock products, particularly by the rapidly growing urban populations in Asia and parts of Sub-Saharan Africa; the prominence of livestock as a significant household asset, particularly for women in certain country contexts; and the significant contribution of livestock emissions to agricultural sectoral emissions are all acknowledged to be critical issues. A critical question is whether CGIAR's livestock research, primarily led by ILRI but also by another nine Centers, has provided improved technologies of value to farm households and the types of impacts (beyond productivity) that this has had on farmers and consumers, particularly the poor among them. A response to this question may then help assess if continued research on livestock is likely to generate high returns. For the purpose of the review, the authors solicited impact assessments of livestock and livestock-related research in the CGIAR from CGIAR Centers and SPIA. Of the 159 studies that were thus assembled, they used two cut-off criteria – reflecting methodological approach and rigour – to identify epIAs and the credible ("eligible") ones among them.

The review confirms that the perceived lack of evidence on impacts of livestock and livestock-related research in the CGIAR is by no means indicative of low level of investments. To the contrary, considerable financial resources (around US$ 1 billion,

unadjusted for inflation) have been allocated to this research area in the CGIAR since about 1990. Nor does it necessarily indicate a lack of intent to measure (potential) impacts. While the number of studies identified by the authors for this review was by no means excessive (the objective was not to do a systematic literature search), they identified some 43 studies that they considered to be eligible epIAs (estimated the returns to research investment) or other empirical studies that assessed components of ex post impact, e.g., propensity score matching, randomized control trials, adoption and learning IAs that were related to livestock and associated research.

A key finding of the review is the limited rigour in the methods used to measure the impacts of livestock research activities, even among the potentially relevant empirical studies. In fact, a significant number of the empirical studies submitted by the Centers (31 in number) did not even qualify – by the reviewers' standards – as epIAs. So, a clear message emerging from this report is the dearth in quantity and quality of the studies submitted to or found by the authors. Only twelve studies were judged to be credible epIAs (or "eligible epIAs"), i.e., that estimated returns to research investment and met key IA criteria standards. All but two of these 12 studies found positive returns to research, with an estimated internal rate of return between 6% and 71%. The authors note that these reported benefits are likely a significant under-estimate of the impacts of investment downstream, and do not factor in externalities (positive and negative) associated with the uptake of livestock-related technologies. This is perhaps true of many, if not most, epIAs, and simply confirms the complexity and difficulty of the task in systematically and effectively disentangling various direct and indirect economic, social and environmental impacts likely to play out after adoption of a given technology on a significant scale.

One of the reasons for the low number of eligible epIAs in the review relates to the authors' use of a subset of SPIA-developed IA external review and quality rating criteria. Of the eleven SPIA-defined criteria considered relevant for assessing the quality of an epIA (Appendix 2), five criteria (the five identified by a subset of donors to the CGIAR as high priority in a 2014 survey) were the ones used by the authors to establish whether the studies received could be considered epIAs. Those criteria were:

i. reliable and representative data on adoption;
ii. plausible impact pathway;
iii. reliable and representative data on yields, incomes, other outcomes and benefit-cost analysis;
iv. sound attribution of benefits to research; and
v. transparent and reasonable assumptions.

Any study not meeting at least four of these five criteria fell out of consideration as an epIA. These are strong and fairly restrictive exclusion criteria.

SPIA notes that there is, in any systematic review of this kind, a trade-off between the quantity and quality of evidence to be considered. In this case, it could be argued that the eleven criteria used in SPIA's review process are meant to provide guidance on what constitutes a high quality epIA. At SPIA, we recognize that many CGIAR impact studies fall short of these criteria in varying degrees, but we feel that nevertheless, some of these studies contain valuable information about impact, and we can often learn about adoption, use, and impact of technologies from studies that are limited in ambition or even flawed in some of their analysis. For instance, there may be useful descriptive information about

adoption even in studies that fail to provide sound measures of impact; but adoption by itself may be an indicator that a technology is valued by farmers.

For this reason, SPIA is reluctant to use any mechanical application of criteria for assessing the quality of an epIA or for excluding such studies from a literature review. For example, while attribution to research is one of the five criteria in the narrow set, SPIA considers the construction of an appropriate counterfactual (what would have occurred in the absence of research) a more important element from a quality perspective. Attribution is, in our view, a secondary issue complicated by the long pathway between research and the types of impacts (poverty reduction, food security, nutrition, environmental sustainability) donors are interested in, and can in fact be sufficiently addressed by good qualitative methods.

Another reason for the low number of "eligible studies" is the requirement for using economic surplus methods to estimate the sector-level benefits associated with an intervention through the calculation of producer surplus as the gold standard for epIAs. None of the other 31 studies that may have passed the first cut-off criteria were reviewed in as much detail as the 12 epIAs that provided information on returns to investment. SPIA agrees that studies that estimate economic surplus provide a valuable picture of research impacts and returns to investment. But as the authors rightly note in the following document, not all impact reports require the use of these models, as many types of livestock domains are considerably more nuanced in their impacts and benefits. But we would add that even where economic surplus has been calculated, such models often rely on empirical data from cross-sectional or other quasi-experimental studies where causal identification may have been problematic. There are also important questions on how demand and prices are modelled: assumptions on the elasticity of demand, how the surplus is split between producers and consumers, and on tradability. Thus, we do not regard economic surplus calculations as intrinsically better than other measures of benefit.

However, taking as given the findings of the following literature review, SPIA joins the authors in concluding that the literature does not provide strong evidence of impact from the CGIAR's past investments in livestock and livestock-related research. Of the twelve studies that form the basis of the following report, none offers evidence that would justify, in aggregate, the investment in livestock research in the CGIAR. That does not mean that there has been no impact, nor does it imply that investments in animal agriculture have been unjustified. It is clear that there are not any studies showing long-term or, large-scale adoption of CGIAR-derived innovations or policies. However, SPIA feels that it is important to note the existence of larger set of micro-level case studies that have examined the link between the adoption of livestock-related technologies /management practices and their direct farm-level impacts (identified in category 2 by the authors). Some of those may offer useful analysis of impacts at the farm level. These too, in SPIA's view, merit serious attention in terms of their potential for adding to the evidence base, understanding constraints to adoption and impact, and feeding a learning agenda.

These qualifiers are not intended to detract from the thoroughness of this review or the importance of the main findings and recommendations. On the contrary, the substantial gaps identified by the review underline the need for building a stronger and more rigorous evidence base in examining the impact of livestock and associated research.

It is important to pause here and ask what one can conclude from the lack of evidence of impact. In a logical sense, the lack of evidence for impact does not imply the absence of

impact. SPIA is unable to evaluate the proposition that the CGIAR's past research on animal agriculture has failed to generate benefits commensurate with costs. There might be many reasons for the lack of evidence on impact. To mention only a few of these, the lack of evidence might reflect:

- Underinvestment in impact assessment studies (i.e., failure to document impacts)
- Time lags in achieving impact (e.g., impacts that have not yet been fully realized)
- Difficulties in attributing changes in complex animal agriculture systems to specific CGIAR research investments (especially a challenge with research on upstream science)
- Methodological and/or logistical challenges in documenting impacts in complex systems (e.g., challenges in distinguishing changes in management practices that reflect CGIAR research, or in identifying impacts on consumers of animal products, where causal chains are long and difficult to trace)
- Sensitivities to claiming impact that might jeopardize relationships with partner institutions.

As a result, SPIA cautions against interpreting the results of this study as evidence for no impact. The distinction between having evidence that there's been 'no impact', and there not being evidence of impact is important to make, but hard to do. Looking ahead, given the difficulties in measuring and documenting impacts, a first priority should be undertaking a serious effort to credibly track adoption of improved livestock related techonologies where the situation warrants.

The authors of this study rightly note that much needs to be done to improve the evidence base for impacts of CGIAR livestock and livestock-related research. They point out that even for those studies that they view as potentially informative (e.g., among the micro-studies that they designate as category 2), sample sizes appear insufficient and none of the quasi-experimental studies applying propensity-score matching was published in a peer-reviewed journal. Future impact assessments will also need to cover the breadth of livestock-related research domains that CGIAR focuses on: out of the ten domains that the authors identified, only four were represented in the twelve epIAs. Even among the additional 83 reports in categories 2 and 3, policy context (index-based livestock insurance) and livelihoods/gender aspects were predominant. Pastoral and animal feed systems, animal disease control, and food safety in livestock value chains are some of the more significant research areas that remain seriously under-evaluated. The type of documentation that would allow impact assessments over longer timeframes and at different levels (household, sector, national) is also lacking. Indeed, there is even little information available on the amount of research investment in particular topics.

SPIA would like to thank Samuel Jutzi and Karl Rich for their thoughtful and comprehensive work that will serve as an important reference for livestock and livestock-related impact assessment work in the CGIAR. Their report highlights a significant lack of evidence on impact, and we leave it to others both to develop the evidence base and to query the reasons why there is so little convincing evidence after forty years of CGIAR investment in this area.

We also gratefully acknowledge the Centers that provided budgetary data and IA reports on livestock and associated research despite the numerous calls on their time, and despite a recognition that this report might lead to a critical assessment. One of the hallmarks of the

CGIAR has long been the willingness of scientists and research managers to face difficult realities and to learn from past experiences, both positive and negative. Although the review identifies numerous gaps in the impact assessment literature on livestock research, we note that there are intrinsic difficulties in assessing high-level impacts (poverty, food security) of agricultural research.

In closing, we also note that many CGIAR research programs and Centers have operated over the past decade or more in an environment where much of their funding is project-based and where it is difficult to implement research designs that can lead to convincing estimates of impact. SPIA notes that without significant changes in this funding environment and the accompanying managerial focus on short-term projects, it is difficult to see how credible impact evidence can be accumulated. This is not simply an issue of budgets for impact assessment studies themselves; instead, a coherent impact assessment strategy will also involve changes in the way in which technologies are developed, tested, and taken to the field. These issues go beyond livestock research, and they reflect the changing realities of impact assessment across the development community. Standards of evidence have risen and the burden of proof is higher than ever. It is not clear that the agricultural research community can ever meet the most rigorous standards of evidence, but equally clear that development institutions, including the CGIAR, will be asked to deliver more and better evidence of impact.

Doug Gollin
Professor, Oxford University and Chair, SPIA

Executive Summary

This study was undertaken to appraise the efforts made in the past quarter century by the CGIAR System to document impacts of its livestock-related research. This research has been identified by SPIA (Standing Panel on Impact Assessment), the unit in charge of guiding and advising impact assessment by the CGIAR Consortium, as one of the under-evaluated areas of work. This initial review was to prepare the groundwork for a suggested subsequent scoping study expected to assess the potential for utilizing state of the art approaches and possibly new data for launching detailed impact assessments of specific improved management related interventions or policy actions deriving from CGIAR research on this research domain.

While the study process recognized that the bulk of livestock-related research in the CGIAR was and is undertaken by ILRI and by ICARDA (drylands, small ruminants), an additional eight CGIAR Centers (ICRISAT, IRRI, CIMMYT, CIAT, IITA, CIP, ICRAF, and IFPRI) were invited to submit their respective *ex-post* impact assessment work, and an account of their financial investments in this research, given their occasional and/or continuous involvement in livestock-related research independently and/or in collaboration with other Centers and partners.

In the analysis of the reports received by Centers, the SPIA-developed criteria for *ex-post* research impact assessment were used. These criteria emphasize inter alia reliable and representative data on yields, incomes, other outcomes and benefit-cost analyses; reliable and representative data on adoption; impact pathway; and sound attribution of benefits to research.

The ten CGIAR Centers provided 159 studies that were associated with elements of impact assessment. Of these reports, 12 studies met the above-mentioned SPIA criteria of *ex-post* impact assessment; nine of them came from ILRI and three from ICARDA. The following summary characteristics and themes emerged: significant impact assessment research has been conducted in the area of technology adoption and management practices of service-related aspects to livestock production (e.g., feed, technology); eight of the 12 studies focused on this theme, with three examining the *ex-post* impact of animal disease interventions and one on commodity marketing. Absent from these impact assessments are analyses of value chains, livestock and the environment, livestock and the society (e.g. poverty alleviation), and livestock production technology.

Except for the two studies on broadbed maker (BBM) plough adoption, all studies found positive returns to livestock-oriented research/interventions. The 12 studies generally represent a diversity of national or regional public goods in terms of their contribution to policy debates in the specific livestock domain considered. However, with the exception of the rinderpest study that examined a global intervention with wide-ranging implications on interventions in disease control efforts in general, most of the other studies are context (product, technology, location)-specific and thus have rather modest global impact. The narrow application of these studies makes generalizing broad lessons for scaling out difficult. A number of studies provide international public goods (IPGs) from a methodological perspective. The forages, cowpea, and dairy marketing studies of ILRI demonstrate increased innovation in the use of economic surplus techniques. The former two utilize GIS and bio-economic platforms to guide the computation of benefits, while the

latter incorporates issues of policy processes in the computation of economic surplus that had not been previously developed in the literature. The rinderpest study provides an innovative expanded approach to conducting *epIA* at different levels of impact, while the ICARDA studies highlight the integration of bio-economic modeling perspectives. Only four of the studies were published in peer-reviewed journals, with the remainder either found in Center-based research reports or reports to donors. On the basis of research impact using citation count measures from Google Scholar, only three of the 12 studies had 25 or more citations, with two of these three published after 2007.

Based on the (incomplete) feedback from Centers, the total amount of resources provided by the CGIAR donors for livestock-related research since 1990 is estimated at around USD 1 billion. Considering this substantial amount, the comparatively limited range, reach and depth of the *epIAs* presented confirm SPIA's assertion that the CGIAR System's livestock-related research is an under-evaluated area in impact terms. An important research component that emerges from this review is the need to couch the advances that have been identified on issues of measuring the benefits and effects of livestock-related interventions into an impact assessment framework **(Recommendation 1: incorporate methodological advances in *epIA*)**.

While many of the additional studies reviewed provide important policy lessons on issues of inter alia learning, adoption, and training, they fail to translate these findings into measurable impacts that address returns to donor investments. The study team recognizes that research impact reports do not necessarily require that all research fall into the exclusive use of economic surplus models, as many types of livestock domains are considerably more nuanced in their impacts and benefits. What it does require, however, is a process of documentation in medium- and large-sized investments in livestock that allows the measurement of a range of benefits at farm, sector, value chain, and/or national levels that can be justified rigorously and weighed against the costs of donor investment. This report has therefore also commented on reports received from the Centers with respect to a range of other methodological approaches applied to impact assessment, and it highlights a few of these findings.

The study team concludes that the integration of research across Centers in multi-year CRPs could provide an opportunity to develop an advanced, systematic process of implementing and conducting *ex-post* impact assessment, and it considers that this would need to be mainstreamed, preferably in the context of a Consortium-wide livestock research framework **(Recommendation 2: integrate impact-focused livestock-related research across centers and CRPs in a CGIAR Consortium-wide framework)**.

1. Background and Purpose of the Study

This study was commissioned in April 2015 by the CGIAR Independent Science and Partnership Council's (ISPC) Standing Panel on Impact Assessment (SPIA). SPIA's task is to undertake assessments of the impacts of the research done by the CGIAR Centers and their partners. In response to growing donor interest in impact assessment of CGIAR research outputs, SPIA has developed a set of activities for Strengthening Impact Assessment in the CGIAR (SIAC, 2013-2016).

This study was undertaken under Objective 3 of the SIAC programme, where activity 3.3. targets *ex-post* impact assessments (*epIAs*) of under-evaluated areas of CGIAR research, such as livestock, irrigation, agroforestry, policy and social sciences, biodiversity and natural resource management. The study was tasked to evaluate the extent and quality of *ex-post* impact assessment (*epIA*) activity on livestock-related research in the CGIAR to-date.

Livestock-related research encompasses a broad area of CGIAR research activities (e.g. animal genetic resources conservation, improvement and use; animal health and related human health; crop-livestock interactions; livestock feed resources improvement, management and use; animal power for land tillage and for transportation; manure for crop nutrition and for fuel; livestock-environment & climate change interactions; livestock value chains; animal source food and human nutrition & health; livestock sector policy & institutions, etc.). A significant part of the CGIAR livestock-related research has historically been conducted by ILRI and its predecessors ILCA and ILRAD, in addition to ICARDA for dryland and small ruminant systems. Given the broad livestock sector research domain, other Centers have invested in specific aspects of this research (CIAT, CIP, CIMMYT, ICRISAT, IFPRI, IITA, IRRI, World Agroforestry). Despite the substantial investment of the CGIAR in livestock-related research (around 1 billion USD since 1990, Table 2 below), relatively few published studies measuring and documenting the impact of this investment *ex-post* are available.

The Terms-of-Reference (Appendix 1) for this desk study suggest identifying the strengths and limitations of the few available livestock-related research impact assessments (in terms of scale effects, rigor of causal relationships, or how close the impact indicators of the studies correspond to the System-Level Outcomes of the reformed CGIAR system). The desk study would also seek to identify the major constraints and limitations in terms of methods, data availability, resources, etc., which would in turn highlight potential for new work on impact assessment. This initial background review should lay the groundwork for a subsequent scoping study which would assess the potential for utilizing state of the art approaches and possibly new data for launching detailed impact assessments of specific improved management related interventions or policy actions deriving from CGIAR research on this under-evaluated area.

Specific objectives of the study are to provide:

(1) An estimate of the total investment in livestock related research and related activities within the CGIAR since about 1990.

(2) A review of what the CGIAR has done in assessing the economic, social and environmental impacts of CG research in the area of livestock management. The review should make critical judgments about the credibility/rigor and scale of those

studies relative to the total amount of investment. This should include identification of gaps (i.e. research 'successes' that do not feature in the impact assessment literature) and weaknesses in the reviewed studies, some of the promising methods and approaches used to-date, and key challenges in assessing large scale, long term impacts of CGIAR research in this area.

(3) A summary of the estimated economic, social and environmental impacts (or influence) documented by the IA studies deemed to be reasonably credible, whether in quantitative and qualitative terms.

(4) Based on survey or even anecdotal evidence, identification of management interventions or policy actions deriving from specific lines of CGIAR livestock related research that appear to warrant serious attention for future adoption and impact assessment studies.

Section 2 of this report puts the study in the general context of the CGIAR Strategy and Results Framework and the System's policies, procedures and programmes for advancing research impact orientation; it also defines the livestock-related research domain as applied to this review. Section 3 provides the approach and methodology used. Section 4 presents and discusses the results, and Section 5 submits conclusions and recommendations.

2. Context

2.1 Mission and System-Level Outcomes (SLOs) of CGIAR research

In May 2015, the CGIAR Consortium Board approved the CGIAR 2015-2030 Strategy and Results Framework (SRF): Harnessing New Opportunities. This strategic update is associated with the launch of the second phase of the CRP portfolio design which will take a more coherent approach to CGIAR's contribution to achieve targets laid out in the SRF towards addressing poverty, malnutrition and environmental degradation; previously dispersed systems' activities will be integrated into eight Agri-Food Systems CRP platforms (among them the Livestock Agri-Food System) supported by four Integrating CRPs (Climate Change, Nutrition and Health; Water, Land and Ecosystems [including soils], and Policies, Institutions and Markets). The Agri-Food Systems CRPs are also expected to systematically link up with each other in important areas of synergy and complementarity.

The SRF 2015-2030 defines three System-level Outcomes (SLOs), and identifies at the same time, the dimensions of these outcomes, thereby clearly suggesting explicit, systematic impact considerations in programme design and delivery:

(1) Reduced poverty: *Help 100 million people, of which 50% are women, get out of poverty*
(2) Improved food and nutrition security for health: *Ensure that 150 million people, of which 50% are women, meet minimum dietary energy requirements*
(3) Improved natural resource systems and ecosystem services: *Restore 190 million hectares of degraded land by 2030*.

The desk study, reported on here, on livestock-related research impact assessment, is tasked with establishing the record of CGIAR's relevant efforts in documenting outcomes and impacts of its livestock-related research in the past 25 years; it is also expected to draw conclusions from such analysis for use in orienting future work to help achieve these ambitious System outcomes. It will be argued that the very broad research domain to be

applied to livestock-related research (due to livestock's multi-functionality and its essential reliance on plant germplasm and related land) requires particularly intense linkages between the Livestock Agri-Food System and other Agri-Food CRPs (CGIAR Research Programmes) in terms of both research delivery and reporting on research impact. Reference in this context is made to the 2014 ISPC White Paper Strategic Review of Livestock in the CGIAR which recommends that the CGIAR would benefit from a System-wide strategic framework for livestock-related research that is apart and beyond the ILRI strategy for 2013-2022.

2.2 CGIAR research impact assessment

The *Standing Panel on Impact Assessment (SPIA)*, which has commissioned this study, is a sub-group of the *CGIAR Independent Science and Partnership Council (ISPC)*; SPIA has an advisory role, primarily to CGIAR members through the *Fund Council*, on issues relating to the quality, relevance and impact of CGIAR research activity.

SPIA's mandate is to

(1) provide CGIAR members with timely, objective and credible information on the impacts at the system level of past CGIAR investments and outputs in terms of the CGIAR goals of enhanced food security, poverty alleviation and sustained natural resources
(2) provide support to and complement the CGIAR Centers in their *ex-post* impact assessment activities; (this includes facilitating inter-Center impact assessment efforts and providing a forum for exchange of experience from impact studies)
(3) provide feedback to CGIAR priority setting and create synergies by developing links to *ex-ante* assessment and overall planning, monitoring and evaluation functions in the CGIAR.

SPIA, since its establishment in 1996, and others have provided guidance on methodological approaches and their use with focus on *ex-post* research impact assessment (e.g. Kelley et al., 2008; de Janvry et al., 2011, further texts under References, Sub-Section C). Evidence of CGIAR research impact accumulated over time, although with notable focus and assessment quality on CGIAR mandate food crop research impact (Renkow and Byerlee, 2010). Impact evidence of research done, however, in areas of policies & institutions, of natural resources & environment, and on livestock-related issues was much less prominently available. This situation (related to livestock research) notwithstanding, substantial efforts to capture impact and adoption dimensions of such research have been undertaken in a rather wide array of methodological approaches (References, Sub-Sections A and B).

SPIA's major initiative (SIAC, 2013-2016) addresses such deficiencies in impact evidence across the CGIAR research portfolio and pursues four related objectives: (1) **Methods**: Develop, pilot and verify innovate methods for collection and assembly of diffusion data; (2) **Outcomes**: Institutionalize the collection of diffusion data needed to conduct critical CGIAR impact evaluations; (3) **Impacts**: Assess the full range of impacts from CGIAR research; (4) **Building a community of practice**: Support the development of communities of practice for *epIA* within the CGIAR, and between the CGIAR and the development community more broadly.

This desk study was commissioned under SIAC Objective 3 where, among others, special attention is given to the strengthening of impact assessment in research areas identified as under-evaluated – livestock-related research has been identified by SPIA as one of the areas

requiring more attention. In its analysis of the reports received from the CGIAR Centers addressed, the study applied the quality assurance criteria prepared by SPIA for *ex-post* impact assessment reports; it also took account of the donor feedback (2015) on the prioritization of these criteria.

The strengthening of impact assessment across the CGIAR portfolio of research is of evident strategic interest to the System's donors and partners when decisions on investments and collaboration are prepared (e.g. Raitzer and Kelley, 2008).

2.3 Defining the livestock-related research domain for impact assessment

Livestock-related research is characterized inherently by a rather broad array of disciplines to be mobilized in the preparation, validation and use of technological and policy solutions required by the sector. This broad domain of livestock-related research is conditioned primarily by the following aspects:

(1) Essential reliance on plant genetic resources and the related land use for the production of animal feedstuff (pastures; range; crop by-products; one third of global crop land is used for feed grain production)
(2) Multi-functionality of livestock – of particular importance in smallholder systems (food, commodity, asset/saving, socio-culture; energy [power, fuel], plant nutrients [manure]; roughage use & transformation, etc.)
(3) Environmental and climate change linkages & impacts; ecosystem services (e.g. grassland as carbon sink, etc.).

The identification and the generation of the relevant metrics for *ex-post* impact assessment are a correspondingly demanding task, both in terms of the diversity and complexity of target technologies and policies, and in terms of resources required. Thus, the comparative paucity of data (both at household and sector levels) in the preparation of hard impact evidence of livestock-related research.

The study reported on here applied the following definition of the livestock-related research domain in its search and analysis (across the CGIAR) of impact evidence:

Table 1. Livestock-related research domain.

Domain field
(1) animal genetic resources [farm animals] - diversity, breeding, management and use
(2) animal and veterinary public health, including food safety
(3) animal feed and nutrition (feed grain crop development, feed-food crop development, forages / pastures, food crop development [investments in maintaining/enhancing feed value of straws and other by-products], multi-purpose trees for feed, supplements, animal nutrition)
(4) livestock production systems; crop-livestock production systems; range/pasture management
(5) commodities (milk, meat, eggs, hides and skins, non-food; processing/value adding, market, trade, retail); manure (crop fertilization, fuel), animal traction (transport, tillage)
(6) livestock sector policy (institutions/organizations, legislation, environment, health, markets, trade, services, credits, subsidies, etc.)
(7) livestock and society / economy (GDP, poverty/equity, gender, resilience, non-food dimensions)
(8) animal-source food and human nutrition and health
(9) natural resource management in livestock production; livestock and the environment
(10) livestock and climate change

3 Approach and Methodology

Recognizing the broad domain to be applied to the CGIAR livestock-related research, the chair of SPIA elicited assistance from the Directors-General of 10 CGIAR Centers and from the Director of CRP Livestock and Fish (CRP 3.7) to provide relevant impact studies from their research, dating back to 1990. The Centers approached are: ILRI, ICARDA, ICRISAT, IRRI, CIMMYT, CIAT, IITA, CIP, ICRAF, and IFPRI. The Centers were also requested to identify the resources they had allocated to livestock-related research for the same time period. In addition to the reports provided by the Centers, relevant websites (SPIA, ISPC) were searched for additional materials. SPIA provided further reports and background documentation.

3.1 Estimation of CGIAR's investments in livestock-related research since 1991

Centers (DGs and their focal points for Impact Assessment) were invited to assess the share of their budgets allocated to livestock-related research in the five 5-year periods since 1990; the IFPRI managed ASTI website (http://www.asti.cgiar.org/cgiar-data/cgiar) was used as reference.

3.2 Identification of reports/studies of *epIAs* on CGIAR's livestock-Related Research

The reports received from Centers and from SPIA/ISPC were screened for eligibility as *ex-post* impact assessments using the SPIA external review and quality scoring mechanism to be applied to impact assessments (Appendix 2) [source: Providing quality assurance for ex post impact assessment studies done by or on behalf of the CGIAR: introducing an external review and quality scoring mechanism (SPIA DRAFT 28 February 2014)]: reports/studies were considered in the review as eligible *ex-post* impact assessments when they satisfied at least 4 of the 5 highest priority SPIA IA criteria as identified by the 2014 donor feedback to SPIA on the epIA quality assurance; these were the priority criteria 7, 6, 3, 9, and 2, as listed in Appendix 2):

- Reliable and representative data on yields, incomes, other outcomes and benefit-cost analyses
- Reliable and representative data on adoption
- Impact pathway
- Sound attribution of benefits to research and, if relevant, attribution to specific institutions
- Transparent and reasonable assumptions

The "*gold standard*" that is often applied in the context of *epIA* is the use of economic surplus models that estimate the sector-level benefits associated with an intervention through the calculation of producer surplus (Lynam et al. 2009 – ILRI CCER on IA). In computing producer surplus measures, the direct and indirect impacts associated with an intervention can be more rigorously teased out. These sector-level benefits are subsequently weighed against the costs associated with the intervention as a means of providing guidelines on the returns to the intervention, summarized through investment

metrics such as net present value (NPV), internal rate of return (IRR), and/or benefit-cost ratios (BCRs).

The study team's assessment of what constituted an *epIA* does not necessarily preclude the use of other measures to compute benefits. Indeed, in a number of livestock domains (e.g., food safety, animal health, value chains), the strict computation of producer welfare measures may either not be appropriate and/or not fully reflect the benefits associated with an intervention. While we have considered the application of different measures to address intervention benefits, we have quite strictly applied the criteria that selected papers *must* highlight the *returns* associated with the considered investment– any concession on this dimension would fall short of SPIA's criteria on research impact assessment and of the Terms of Reference of the study; it would also diverge from the approach used by the 2014 study on irrigation and water management (Merrey report). Therefore, many otherwise acceptable studies were not included in our final assessment because they failed to weigh the benefits measured (e.g. adoption rates, learning rates) in an impact assessment framework that allows donors to assess the cost associated with achieving the benefits identified. Nevertheless, a few of such reports on research output adoption and welfare impact without explicit reference to returns on related investments are highlighted in Section 4.2, and an annotated listing of studies under the full array of methodologies applied is given in Appendix 5.

4. Results

4.1 Investments in livestock-related research (1990 – 2015)

Table 2 records the financial resources invested in livestock-related research as notified by the Centers. It is noteworthy that in the context of the CGIAR System-wide Livestock Programme (SLP) which was a consortium of 12 international agricultural research centers and their partners (activities ended in December 2012), livestock-related research was carried out, funded through ILRI, also by Centers listed which have not communicated respective budgets. Similarly, ILRI-budgeted resources may also have been allocated to other inter-Center collaboration on livestock-related research, e.g. in the context of the CGIAR Ecoregional Programmes and Challenge Programmes.

From the (incomplete) data reported in Table 2, it appears safe to estimate the total amount of resources provided by the CGIAR donors for livestock-related research since 1990 at around USD 1 billion. A closer, though presumably rather tedious historical analysis of the budgets of some CGIAR Centers might yield additional resources allocated to such research (e.g. ICRISAT's draught animal power research in Vertisol management; commodity Centers' investments in balancing grain/crop residue traits in crop development, etc.). For the purposes of this study, however, the USD 1 billion figure is suggested as the benchmark.

Table 2. Resources invested in livestock-related research since 1990.

Center	Investment (USD millions)
ILRI	869.9
ICARDA	10.9
ICRISAT	n.a.
IRRI	n.a.
CIMMYT	n.a.
CIAT	39.5
IITA	n.a.
CIP	0.95
ICRAF	n.a.
IFPRI	0.25
Total	**948.5**

4.2 Impacts documented by *epIAs* identified

The few studies identified in this review that satisfy the criteria applied to *ex-post* impact assessments do not really allow to document comprehensively ¨*what the CGIAR has done in assessing the economic, social and environmental impacts of CG research in the area of livestock management*¨ as requested by the TORs of the study. Nonetheless, our review has tried to accomplish the following:

(1) Identification of studies that meet the criteria defined in section 3.2;
(2) An assessment of the quality and impact of the studies that meet the criteria defined in section 3.2;
(3) Identification of studies that, while not meeting the criteria defined in section 3.2, provide methodological inputs that could be integrated in future *epIA* studies.

We obtained a total of 159 studies associated with elements of impact assessment that were provided to us by the CGIAR centers addressed. Of these studies, we identified 12 studies that met the criteria of *ex-post* impact assessment as defined in section 3.2. Nine of these studies came from ILRI and three from ICARDA. Of the 12 studies identified in our review, five were previously identified in the 2009 CCER review of ILRI or are updated versions of the papers in the CCER review (e.g., we used the Kaitibie et al. (2010) study published in *World Development* instead of the ILRI research report cited in CCER). Appendix 3 provides a summary evaluation of these *ex-post* impact assessment studies on CGIAR livestock research identified, while Appendix 4 provides a characterization of these reports, thereby ¨*making critical judgments about the credibility/rigor and scale of those studies*¨ (TORs #2).

For the 12 studies highlighted as eligible as *epIA* studies, a number of characteristics and themes emerge:

- Significant impact assessment research has been conducted in the area of technology adoption, management practices of service-related aspects to livestock production (e.g., feed, technology), and crop/livestock systems. Eight of the 12 studies focused on this theme, with three examining the *ex-post* impact of animal disease interventions, and one on commodity marketing;
- Absent from these impact assessment studies were analyses of value chains, livestock and environment, livestock and society, and livestock production

technology. However, several of the papers that were not selected as pure *epIAs* address these issues (see below and Appendix 5), though more research is needed to enhance impact assessment along these domains, particularly as metrics for many of these domains are multi-faceted, difficult to quantify, and have impacts that traditional methods may miss;

- Economic surplus methods, highlighted as the "*gold standard*" for conducting *epIA*, were used in six of the 12 studies. Two of the animal health studies (both on avian influenza) used more rudimentary benefit-cost techniques, while the study on *rinderpest* and studies from ICARDA utilized a mix of bio-economic and standard economic models to calculate impacts;
- Other than the two studies on the broadbed maker (BBM) plough adoption, all studies found positive returns to livestock-oriented research/interventions. The 2008 BBM study, which represented an update of the earlier (2001) study findings that were strongly negative, appears problematic as it reported contradictory results: e.g., a benefit/cost ratio that was positive at 3.3, but a net present value that was negative at -1 million USD (see p. 29 of Rutherford et al. (2008));
- The 12 studies generally represent a diversity of national or regional public goods in terms of their contributions to policy debates in the specific livestock domain considered. However, with the exception of the *rinderpest* study that examined a global intervention with wide-ranging implications on interventions in disease control efforts in general (albeit in the context of selected country case studies), most of the other studies are context (product, technology, location)-specific and thus have rather modest global impact. The narrow application of these studies makes generalizing broad lessons for scaling out difficult;
- A number of studies provide international public goods from a methodological perspective. The forages, cowpea, and dairy marketing studies of ILRI demonstrate increased innovation in the use of economic surplus techniques in the context of impact assessment. The former two utilize GIS and bio-economic platforms to guide the computation of benefits, while the latter incorporates issues of policy processes in the computation of economic surplus that had not been previously developed in the literature. The *rinderpest* study provides an innovative expanded approach to conducting *epIA* at different levels of impact that could aid in the modeling of intervention benefits in a number of livestock domains, while the ICARDA studies highlight the integration of bio-economic modeling perspectives. On the other hand, the two avian influenza studies of ILRI are much more modest in their methodological contributions, while the two studies on broadbed maker plough adoption are particularly weak in their application of economic surplus techniques;
- Only four of the studies (Kenyan dairy, avian influenza in Nigeria, *rinderpest*, spineless cactus in Tunisia) were published in peer-reviewed journals, with the remainder either found in Center-based research reports or reports to donors that were not refined further;
- On the basis of research impact using citation count measures from *Google Scholar*, only three of the 12 studies had 25 or more citations, with two of these three published after 2007. Just five of the 12 studies had more than 10 citations.

Brief summaries on the selected *epIA* studies are given below:

1) USAID (2009): This study examined the operational research programme for Highly Pathogenic Avian Influenza (HPAI), focusing on the returns and cost-effectiveness of HPAI mass vaccination campaigns delivered in 2008-2009. The approach is a technical benefit-cost analysis that used programmatic costs and epidemiological techniques to guide the measurement of costs and benefits to compute the cost-effectiveness of the intervention. The study does not consider economy-wide or sector-level impacts as computed through an economic surplus model. A range of sensitivity or scenario analysis was also not conducted. BCRs for mass vaccination were found to be less than 1 (0.16-0.44 depending on the programme). While straightforward methodologically, the paper did not address the indirect impacts associated with mass vaccination or issues of socio-economic adoption or uptake that could influence study results.
2) Kaitibie et al. (2010): This study examined the impact of ILRI's Smallholder Dairy Programme (SDP) in Kenya, which aimed at liberalizing informal milk marketing in Kenya and documenting the policy processes associated with the intervention. An interesting innovation of this study was in its attempt in quantifying policy processes, and assessing different counterfactual scenarios related to delays in policy implementation. This paper used an economic surplus model to compute economic benefits, with shifts in the supply curve in milk markets attributed to policy change dynamics. The authors reported a baseline net present value of USD 230 million over 1997-2039 and an IRR of 55%. Methodologically, this paper makes strong contributions in trying to frame policy change in a quantitative context, although future research will be needed to more finely tease out and attribute specific policy changes to intervention benefits.
3) Kristjanson et al. (2008): This study looked at the impact of dual-purpose cowpea adoption in West Africa. While this study used standard economic surplus methods in its design, a particularly interesting innovation is the combination of participatory qualitative approaches with a crop model and GIS techniques to spatially target and quantify the distributional impacts of the intervention. Baseline model results revealed an NPV of USD 606.4 million from the intervention over 20 years, a benefit-cost ratio of 63.2 and an IRR of 71%. This study has been widely cited (38 citations since publication) and represents an integration of the research strengths ILRI has had in the areas of spatial analysis, livelihoods targeting, and economic modeling. More fine-tuning of the analysis, in terms of applying probability distributions on uncertain parameters or considering the impacts on specific household typologies within identified socio-economic domains could have been considered, as could the computation of wider downstream impacts or at the level of the livestock value chain more generally.
4) Fadiga et al. (2014): This paper looked at the *ex-post* impact associated with the World Bank's intervention on HPAI in Nigeria. In this model, a stochastic epidemiological model was used to parameterize counterfactuals of disease evolution in the absence of disease control and under different risk scenarios. Unlike the Kaitibie or Kristjanson papers, an economic surplus model was not used; rather, a simple model of direct costs was used alongside the use of a simple multiplier to

compute downstream effects. This means that issues of price responsiveness were not considered directly, so that benefits are potentially under-reported. The study also did not report the impacts of all scenarios nor did it consider the probability of different scenarios arising. The results indicated net benefits of HPAI control versus a situation of endemic, high-mortality HPAI of USD 27.22 million over a five-year period and a BCR of 1.75.

5) Elbasha et al. (1999): This paper was covered in the ILRI CCER of 2009 and is similar to the Kristjanson model in spirit, although it is not as comprehensive from a methodological standpoint. This paper examined the impact of establishing fodder banks by agro-pastoralists as a means of supplementing feed resources and improving animal nutrition in the dry season. An economic surplus model was used for different livestock markets (milk, meat, and feed grains) to establish the impact of the intervention, although interactions (as in a multi-market model) between markets were not considered. Unlike the Kristjanson model, socio-economic impacts to assess distributional impacts were only conducted at a country level. Baseline results revealed a net present value of USD 11.8 million, a BCR of 3.3, and an IRR of 38% over a 20-year period. Projections to 2014 suggested a net present value of benefits ranging from USD 65 to 81 million.

6) Rich et al. (2014): This paper examined the *ex-post* impact of rinderpest eradication, focusing on two case studies of eradication in West Africa (Chad) and India. An important innovation of this study was methodological, in terms of identifying various levels of impact from the producer-level to national/international levels, and mechanisms and tools to address these. Data limitations confined the study to examining farm-level impacts, through the use of a herd demographic model (DynMod) developed at ILRI, and CGE models to look at macroeconomic impacts. Different counterfactual disease scenarios were simulated to assess the impact of eradication against alternative scenarios. In Chad, baseline BCRs associated with eradication were 4.02 over 1963-2002, with different mortality assumptions giving a range of -5.83 to 47.15. In India, the paper distinguished between impacts during different intervention periods, with the final stage of eradication yielding high BCRs (over 64) given the strong market access benefits associated with eradication.

7) Rutherford et al. (2001; 2008): Both of these studies examined the impact of the broadbed maker plough in Ethiopian farming systems for surface drainage of readily water-logging Vertisols which represent large parts of the highland soils. The 2008 study extended some of the results from the earlier 2001 study, which found strong, negative impacts (NPV of –USD 12.6 million, BCR of 0.01) associated with technological uptake. Like the Elbasha and Kristjanson studies, primary survey data on adoption and metrics of performance were used to generate economic surplus models for the estimation of benefits. However, the computation of a number of these metrics is suspect – as noted earlier, the 2008 study reports a positive BCR but a negative NPV and an IRR well below 1, which is mathematically inconsistent. Unlike the Elbasha and Kristjanson studies, the economic surplus technique applied in this paper is considerably less sophisticated, with little in the way of sensitivity analysis.

8) Montes et al. (2008): This paper addressed the impact of various projects associated with the improved management of goat production in the Philippines. Like some of the other studies, it applies an economic surplus method, though with considerably less sophistication than the Kristjanson paper in that distributional impacts are only at regional levels and the sampling design is not as thorough as in other ILRI analyses reported above. Paper results indicated a projected NPV of benefits of A$66 million over 2007-2030, an IRR of 25%, and a BCR of 10.4.

9) Alary (2007; s.d.): These two papers addressed the impact of adopting the spineless cactus in alley cropping system in Tunisia. The analysis utilized a modular approach to the development of a bio-economic model of the crop-livestock system, with different modules related to (1) farm production (crops and livestock); (2) household-level decision making on consumption and resource allocation; (3) an integration process of (1) and (2) based on tradeoffs between production and resources; and (4) a recursive optimization algorithm that takes into account risk preferences. This model was applied to six different typologies of farmers and pastoralists, with the impacts on different subsidy regimes and productivity parameters modeled to assess the impact on adoption rates of different farm types and returns to investment. The published paper does not report investment metrics (focusing instead on adoption metrics), while the report to SPIA does. The model is rather complex and while somewhat of a black box in parts reveals an interesting framework for modeling farm-level behavior. It lacks a sector-level interface to compute second-round or indirect effects as in an economic surplus analysis, so benefits are potentially under-estimated. In addition, there is some confusion in the financial measures reported in the SPIA report, with a negative NPV given alongside a positive BCR in one instance.

10) Shideed et al. (2007): The Shideed paper compares the experiences of NRM crop-livestock systems in Tunisia (as discussed above) and the impact of the Atriplex system in Morocco. The focus of both studies was to demonstrate the application of integrating biophysical models with economic ones, and the computation of both financial and economic IRRs, with the latter taking into account the social returns to an investment. As the Tunisia example largely followed the previous discussion, the focus here is on the Morocco model. The Morocco model utilized the SCUAF model (Soil Change Under Agro-Forestry) that was calibrated to NRM data collected from farm surveys and field station trials. This was integrated with economic data from farm surveys to evaluate costs and adoption levels, and which served as the basis for econometric estimates of productivity data. Data from Morocco revealed FIRRs of 50% and EIRRs of 25% for programme areas, with FIRRs and EIRRs nearly double that outside of targeted programme areas (90% and 48%, respectively). The results also highlighted the positive environmental benefits associated with the intervention, which exceeded the subsidy allocated for the program.

In Table 3, we present an overview of the magnitude of research investments associated with the studies highlighted for review as *epIAs* in our analysis. As noted in the Table, most of the projects represented significant investments, although not all of the costs associated with these projects are associated purely with investments in CGIAR research or technology promotion. The costs associated with the two studies on avian influenza and the study on

rinderpest, for example, are primarily programmatic costs of the interventions studied (vaccines, investments, training costs), in addition to critical epidemiological research output provided by ILRI and its partners. Specific breakdowns of CGIAR time in these studies were generally not provided. In the case of the ICARDA studies, none of the studies aggregated total research or investment costs, instead only providing information on the costs per hectare of investments.

Table 4 attempts to address the magnitude of impacts associated with the selected *epIAs*. As noted above, in all cases other than the two broadbed plough papers, the returns to investment are all positive. Strong returns to investment in terms of internal rates of return and net present values were reported in the SDP study (USD 230 million, projected over 1997-2039), dual-purpose cowpea (USD 606 million projected over a 20-year period), parasite control (A$65 million, or approximately USD 50 million, projected over 1999-2030), and rinderpest in Chad (CFA 32 billion, or approximately USD 50 million at farm-level over 1963-2002). However, given the difference in methods used across the different applications, the comparability between studies is more challenging. Moreover, given the application of economic surplus methods in several of the selected papers, the reported benefits likely significantly under-estimate the impacts of investments at downstream or national levels, and do not factor in both positive and negative externalities associated with their uptake. The rinderpest paper is perhaps the closest in trying to tease out more macro-level impacts through the use of social accounting matrices and computable general equilibrium models, although these macro-level impacts are not fully integrated into standard impact assessment metrics such as BCRs, IRRs, or NPVs.

A number of additional studies provided by the Centers were reviewed that demonstrated promise from either a methodological or application perspective in their potential application in *epIA* research in livestock. In Appendix 5, we have classified a subset of these reports (listed in parts (B) and (C) in the References) thematically in addition to the selected *epIA* studies found in Appendices 3 and 4. Appendix 5 classifies studies into three broad themes: (1) *Ex-post* impact assessments that specifically highlight returns to investment (as discussed above); (2) Other studies assessing components of *ex-post* impact but not specifying returns to investment; and (3) Other impact studies not qualifying as *epIAs*.

Table 3. Overview of investment costs of selected studies.

Study	Research and/or intervention investment (USD)	Timeframe	Components of costs
1. Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (project period: 15 August 2007 to 31 December 2009)	2,891,823	2008-2009	Vaccine, investment, training, other intervention costs
2. Kenyan Dairy Policy Change: Influence Pathways and Economic Impacts	5,000,000	1997-2005	DFID, other research partners (US$2.5 million by DFID, US$2.5 million by research partners)
3. Genetically improved dual-purpose cowpea. Assessment of adoption and impact in the dry savannah of West Africa	20,000,000	2000-2009	Research and extension costs
4. An *ex-post* economic assessment of the intervention against highly pathogenic avian influenza in Nigeria	41,000,000	2006-2010	Intervention costs paid by World Bank
5. An *ex-post* Economic Impact Assessment of Planted Forages in West Africa	41,758,000 (of which USD7,226,000 devoted to fodder banks)	1975-1997	Research, extension, and fodder bank costs
6. An assessment of the *ex-post* socio-economic impacts of global rinderpest eradication: Methodological issues and applications to rinderpest control programs in Chad and India	Global costs >USD610 million	Incurred through eradication in 2011	Project, intervention, vaccine, training costs
7. Broad bed maker technology package innovations in Ethiopian farming systems: An *ex-post* impact assessment	63,600,000	1986-2008	Research and extension costs
8. The role of the broadbed maker plough in Ethiopian farming systems: An *ex-post* impact assessment study	See (7) for total cost of project		
9. Management of internal parasites in goats in the Philippines	A$7,490,000	1999-2007	Donor and project costs
10. Promoting the adoption of natural resource management technology in arid and semi-arid areas: Modeling the impact of spineless cactus in alley cropping in Central Tunisia. Agricultural systems, 94(2), 573-585.	Not reported	1999-2004	Not reported
11. ICARDA. *Ex-post* Impact Assessment of Natural Resource Management Technologies in Crop–Livestock Systems in. International Research on Natural Resource Management: Advances in Impact Assessment, 169.	Not reported	1991-1999 (introduction costs); 1999-2015 (dissemination costs)	Not reported
12. *Ex-post* impact assessment of NRM research in the arid and semiarid areas: the case of the Mashreq/Maghreb project experience. Tunisia case study: Spineless cactus in alley cropping	Not reported	1994-2004	Not reported

Table 4. Overview of returns to investment in selected studies.

Study	BCR	IRR	NPV
1. Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (project period: 15 August 2007 to 31 December 2009)	0.16-0.44	N/R	N/R
2. Kenyan Dairy Policy Change: Influence Pathways and Economic Impacts	N/R	55%	US$230 million over 1997-2039
3. Genetically improved dual-purpose cowpea. Assessment of adoption and impact in the dry savannah of West Africa	63.2	71%	US$606.4 million over 2000-2020
4. An *ex-post* economic assessment of the intervention against highly pathogenic avian influenza in Nigeria	1.75	N/R	Incremental net benefit of US$27.22 million over five years
5. An *ex-post* Economic Impact Assessment of Planted Forages in West Africa	3.3	38%	US$11.8 million over 1977-1997
6. An assessment of the *ex-post* socio-economic impacts of global rinderpest eradication: Methodological issues and applications to rinderpest control programs in Chad and India	Chad: 4.02 at farm-level; >18 at national level; India: 0.98-64.77 depending on period	N/R	Chad: 32.46 billion CFA over 1963-2002; India: N/R
7. Broad bed maker technology package innovations in Ethiopian farming systems: An *ex-post* impact assessment	3.3	0.10%	-US$1million over 1986-2008
8. The role of the broadbed maker plough in Ethiopian farming systems: An *ex-post* impact assessment study	0.01	N/R	-US$12.6 million over 1986-2006
9. Management of internal parasites in goats in the Philippines	10.4	24.70%	A$65.5 million over 1999-2030
10. Promoting the adoption of natural resource management technology in arid and semi-arid areas: Modeling the impact of spineless cactus in alley cropping in Central Tunisia. Agricultural systems, 94(2), 573-585.	N/R	N/R	N/R
11. ICARDA. Ex-post Impact Assessment of Natural Resource Management Technologies in Crop–Livestock Systems in. International Research on Natural Resource Management: Advances in Impact Assessment, 169.	N/R	Tunisia: 20-40% (FIRR); 7-15% (EIRR); Morocco: 50-90% (FIRR), 25-48% (EIRR)	N/R
12. Ex-post impact assessment of NRM research in the arid and semiarid areas: the case of the Mashreq/Maghreb project experience. Tunisia case study: Spineless cactus in alley cropping	1.72-23.10 depending on scenario/incentive program	6-57% depending on scenario/incentive program	-75,000-1,405,000 Tunisian Dinars over 1999-2020

Within categories (2) and (3) in Appendix 5, we identified eight methodological themes or sub-categories associated with these reports: propensity score matching (PSM) techniques, experimental approaches (randomized control trials), adoption and learning impacts, other quantitative approaches, epidemiological transmission studies, outcome mapping, innovation platforms, and conceptual frameworks for impact assessment. While many of these papers often highlight innovative means of measuring the effects of studied interventions, all of these studies were excluded from category (1) for failing to couch these effects into broader impact assessment terms on the *return* to the intervention itself. That is, while these studies showed important impact dimensions such as changes in adoption or learning effects, for example, the costs in achieving these benefits in terms of research or project expenditure are not provided, nor are the broader economic effects (direct plus indirect effects) generated by economic surplus-type methods. At the same time, studies in category (2) in particular hold some promise in providing details on techniques that can help in the process of determining impact, though future research utilizing these types of methods should address the returns of obtaining the impact calculated from their approach. A few of the studies in the References that were not classified in Appendix 5 include policy briefs and *ex-ante* impact assessment studies that were outside the remit of this review.

PSM studies and RCTs have been applied in a number of contexts in recent ILRI and IFPRI research as noted in Appendix 5. These studies have been applied in the context of technology adoption (sweet potatoes in China, improved feed in India), forage development in Ethiopia, learning effects in disease control and food safety in Africa, drivers of adoption of index-based insurance in pastoral areas, and the assessment of dairy value chain interventions on gender-specific dynamics. De Janvry et al. (2011) have criticized the application of PSM approaches for their inability to fully tease out the counterfactual between adopters and non-adopters. This important critique notwithstanding, there has been an important shift in CGIAR livestock research in trying to examine more rigorously household-level impacts associated with interventions. These types of studies advance some of the econometric techniques done previously at ILRI (e.g., the smallholder dairy technology adoption studies of Nicholson et al.) and are noteworthy in their application by both economists and non-economists alike to examine a diversity of livestock research domains.

A few examples using these approaches are discussed below.

1) Lapar et al. (2011) employed a propensity score matching technique to assess the *ex-post* impact of the adoption of sweet potato feed technologies in China. Their analysis relied on survey data comparing adopters and non-adopters in six villages, five of which were in exposed sites, and one in a non-exposed site. The authors found a per-farm increase in farm-level gross margins in adopters of at least 2 Yuan per kg live weight and an additional 3-7 pigs produced per year. Regional impacts of the intervention were estimated at 12.6 billion Yuan (USD 1.8 billion). The study further found that the intervention was more suitable in marginal areas that are isolated from markets, and where sweet potatoes are more important than maize in cropping patterns. While this study is unique among the PSM studies in calculating the broader impact of the intervention in question, a few issues in the study were problematic. A major flaw of the analysis is that a majority of econometric results

were not found to be statistically significant, though many of the conclusions were expanded from them. In particular, neither the gross margin per kg nor the output weight comparisons between adopters and non-adopters were statistically significant across production systems. In addition, the degrees of freedom in the sample were relatively small (111 households in exposed areas, 53 in non-exposed areas), particularly across certain production systems (e.g. farrow-wean). The sampling frame for non-exposed households (just one village vs. five for exposed) was not fully motivated or rationalized. While benefits at the economy-wide level were extrapolated, the study did not fully cost out project costs associated with the project itself or in terms of wider uptake of the technology by adopters themselves.

2) Quisumbing et al. (2013) used qualitative and quantitative techniques to assess the impact of dairy value chain level interventions on gender issues, including ownership of assets, gender norms on asset control and decision-making, and time allocation. Propensity score matching techniques were used to examine the differences between test groups and control groups. Study results indicated that value chain interventions increased joint household-level assets (of men and women). On the other hand, while value chain interventions did not alter decision-making norms at the production level, they did have an impact on intra-household decision dynamics. The value chain interventions also increased the amount of time allocated to dairy activities, most of which was borne by women. A strength of the study is that significant efforts were made to disaggregate the various dimensions of impact associated with adoption. Economic results and the sampling frame used were robust. However, as with the Lapar et al. study, the propensity score matching analysis was not couched in impact assessment terms. That is, while impacts were provided in terms of micro-level indicators of participants (net income, marketed surplus, etc.), the returns to the project intervention as a whole were not considered.

3) Grace et al. (2008) provided an assessment on the impact of providing improved information to farmers in the diagnosis and treatment of trypanosomiasis in Mali. Their study design designated both control and test groups, with the latter providing information on retention rates at different intervals of time. Both farmer knowledge and successful treatments were higher in the test group compared to the control group. The analysis used a rigorous sampling design and frame, particularly in a challenging, data-constrained environment. Like the other studies mentioned above, this study was not a true impact assessment from an economic standpoint in that neither the economic benefits nor the costs associated with realizing impacts were quantified. On the other hand, the Grace et al. paper is noteworthy relative to the PSM study of trypanosomiasis control (Liebenehm *et al*. 2009) in that the former tried to measure the association between knowledge and practice, which is often overlooked in the context of measuring *ex-post* impact.

4) Jensen et al. (2014) study the welfare impacts associated with reducing basis risk among pastoralists participating in the Index-Based Livestock Insurance (IBLI) programme in Kenya. Using a four-year household panel dataset that takes into account different seasonal factors and the attrition of households from the programme, the authors find that IBLI reduces exposure to downside risks by over

30 percent after adjusting for covariate losses. While this paper makes some important theoretical and empirical contributions on risk and its potential implications on uptake and adoption, it does not evaluate the returns to IBLI, although a recent paper by Jensen et al. (2015) looked at the costs for participants (though not the programme) in IBLI.

The challenges in the future for this type of micro-level approach, in addition to addressing the sampling and design issues pointed out by de Janvry et al. (2011), are twofold. First, there are significant differences in the quality of PSM/RCT study design and data outputs. Indeed, not one of the papers reviewed that applied PSM has been peer-reviewed in an academic journal. On the other hand, two of the papers using RCT-type techniques were published in the veterinary epidemiology literature, while the papers on ILRI's index-based insurance (IBLI) program have been published as working papers in high-level policy outlets (NBER, IDE) while in review in top academic journals. Secondly, and more importantly, there is a need to translate the benefits attributed to the intervention with impact assessment metrics at more than the household or farm-level. While many of these studies generate results on the impacts at the household level in terms of income gained from the intervention, how these benefits translate into returns to the project investment are wholly absent. In other words, what is not known are (1) the costs required in obtaining the reported benefits and (2) how household-level benefits can be aggregated up to sector- or economy-wide impacts.

A number of studies highlight adoption and learning effects [sub-category (c) in category (2)]. Several of these studies came from CIAT in the context of studies on the adoption of various types of forage technologies, using a variety of methods ranging from descriptive statistics of adoption and learning behavior, the modeling of adoption curves, and the use of econometric methods. While a few of these studies (Bosma, Grace, Holmann) attempted to quantify financially the effects of different interventions, most of the other studies focused more on either adoption measures or behavioral parameters in their analyses. The Grace et al. 2012 study attempts a rather *ad hoc* benefit-cost analysis of the impact of training workshops designed to improve food safety in meat. However, their analysis does not consider *inter alia* project or research-related costs associated with the intervention nor does it rigorously consider the benefits and alternative scenarios associated with their achievement (e.g. different scenarios of adoption, potential decays in learning). As with the PSM and RCT studies noted above, translating the gains from adoption into financial metrics of impacts will be critical to enhance their contributions in addressing the positive impacts of livestock research.

Other studies that were contributed for this study did not qualify as *epIAs* but nonetheless contribute some important elements of impact that should be incorporated in future impact assessment work. For instance an important part of ILRI's research has been examining the epidemiology of various animal diseases and food pathogens. These types of studies provide important contributions both *ex-ante* and *ex-post* on the dynamics of disease, both from a technical standpoint but increasingly from a behavioral standpoint. It is important that these types of inputs are integrated in future *epIAs* in the context of the animal health domain – the papers by Fadiga on avian influenza and Rich on *rinderpest* give some clues on how to assess *ex-post* impacts that account for disease dynamics. Such domains may not lend themselves easily to economic surplus techniques. Nonetheless, developing ways to

quantify impacts, particularly qualitative ones such as behavioral change, will be essential to demonstrate the strong value of this research.

Notably absent from the current suite of studies are those that look at impacts at the level of the value chain. Lapar et al. (2014) come closest to this in the context of the impact of training in food safety in the dairy value chain in northeast India. In this study, they compute a number of metrics to assess whether training provides higher margins and traded volumes among those exposed to training activities. Their results do not clearly demonstrate the benefits of training, with inconsistent results on margins and prices, though the paper shows potential in at least trying to conceive the chain-level effects of a rather nuanced intervention in food safety. A number of the conceptual frameworks provided in Appendix 5 could potentially give guidance on ways to address value chain issues. For example, the paper by Rich and Hamza highlights the role that systems dynamics models could play in both *ex-ante* and *ex-post* impact assessments at the level of the value chain, given their ability to model interactions and feedbacks between animal health, herd dynamics, marketing behavior, and adoption; Thornton makes a similar observation on the use of such models in the context of looking at climate-related impacts. Similarly, the papers by Notenbaert and Ran give additional tools for engaging with value chain level impact assessment. More rigorous methods that capture multi-sectoral impacts, for instance following the *rinderpest epIA,* could be employed in this setting. Moreover, given that public health benefits are an important, understudied impact of food safety and animal health interventions, developing ways that imbed DALYs (disability-adjusted life years) as a metric of impact will be critical to improve future analyses.

Finally, a significant body of received literature consisted of qualitative assessment of different livestock interventions. Particularly prevalent along these themes included the use of outcome mapping and analysis of innovation platforms. The EcoZD project, for instance, looked at behavioral changes among different livestock stakeholders in the control of zoonotic diseases, using outcome mapping (OM) as a means of tracing such changes. While OM is an important tool to assess behavioral change, developing quantitative metrics alongside qualitative participatory processes will be crucial to help gauge the impact of such interventions. Indeed, the SDP *epIA* provides guidance on how to measure change in policy processes within a conventional economic surplus analysis, and could be a template for future OM-type studies. Similar to measuring impact at a value chain level, generating metrics that address the impact of innovation platforms will also be needed. As much of the positive impacts associated with innovation platforms are behavioral and organizational, measures that quantify these will be needed at the level of intervention and beyond.

5. Conclusions and Recommendations

5.1 Investments in livestock-related research

The experience made in the context of this review – with four of the ten Centers addressed not providing any feedback to the request for reports on IA in livestock-related research, and with only five Centers providing, albeit only partial, figures on budget allocation to livestock-related research – suggests that the Centers consider the responsibility for this research to be largely or even exclusively with ILRI / CRP3.7 / ICARDA, with no substantive implication for their Center's programme of work (unless requested – and funded – by ILRI / CRP3.7; the mode of operation of the System-wide Livestock Programme [SLP] and possibly

also of Ecoregional Programmes and Challenge Programmes may have introduced or at least strengthened this perception); the implications of the broad research domain related to the livestock sector appear to be considered secondary for the mandate delivery of these Centers.

Assuming considerable implicit livestock – relevant dimensions in the research of Commodity Centers such as CIMMYT, IRRI, ICRISAT (food-feed crop development, crop residues for feed value and crop by-products for feed value in food crop breeding), or of IITA, ICRAF (dual-purpose crop use, multipurpose trees), it appears safe to assess total CGIAR resource investment in livestock-related research at more than the USD 948 million reported in this review (Table 2).

5.2 Opportunities and gaps in impact assessment on livestock-related research

In terms of the geographic coverage of the selected *epIA* reports, all but two of the reports (avian influenza in Indonesia and parasite management in the Philippines) focused on African cases. However, three of the 10 African case studies covered applications in North Africa. Of the non-selected studies that could be easily classified into a specific geographic region, African case studies also made up a majority (45), compared to 21 Asian examples and just five Latin American ones.

Table 5. Livestock research domain – coverage (*epIAs* in categories 1 and 2; v. Appendix 5).

Sl no.	Domain area	*epIA* report availability (category 1)	*epIA* report availability (category 2)
1.	animal genetic resources [farm animals] - diversity, breeding, management and use	N/A	N/A
2.	animal and veterinary public health, including food safety	4	6
3.	animal feed and nutrition (feed grain crop development, feed-food crop development, forages / pastures, food crop development [investments in maintaining/enhancing feed value of straws and other by-products], multi-purpose trees for feed, supplements, animal nutrition)	4	10
4.	livestock production systems; crop-livestock production systems	3	3
5.	commodities (milk, meat, eggs, hides and skins, non-food; processing/value adding, market, trade, retail)	N/A	1
6.	livestock sector policy (institutions/organizations, legislation, health, markets, trade, services, credits, subsidies, …)	1	6
7.	livestock and society / economy (GDP, poverty/equity, gender, resilience, non-food dimensions)	N/A	5
8.	livestock commodities and human nutrition and health	N/A	N/A
9.	natural resource management in livestock production	N/A	N/A
10.	livestock and climate change	N/A	N/A

In only four of the ten domain areas (Table 5) were there qualified *ex-post* impact assessments as defined in category 1 (although only partially covering the respective domain areas) available; there are therefore significant gaps to be filled across the entire research portfolio. A similar distribution is found for category 2 reports, with more reports proportionally found on policy in the context of IBLI and on livelihood/gender issues. Five

livestock-related domain areas are identified in Table 6 for which strategic scoping studies might be envisaged to help close the considerable gaps identified in impact assessment – Centers and CRPs concerned are listed against these domain fields. At the same time, and as noted above, there has been research conducted particularly in areas related to animal feed systems, food safety, pastoral systems, and animal disease control that, while not meeting the strict definition of *epIAs* in this review, could be harnessed and applied in current or future research. For instance, extensions of ILRI's Safe Food, Fair Food, or the ongoing PigRisk project in Viet Nam on food safety in pig value chains provide opportunities for measuring and documenting the impacts associated with food safety and animal health interventions. Likewise, ongoing research in the Index-Based Livestock Insurance (IBLI) project could be adapted to highlight project impacts and returns. The Livestock AGRI-Food System CRP should further serve as a rich laboratory for conducting impact assessments at a value chain level, which represents a significant gap in impact assessment studies and where there are opportunities for advancements in new methods of measurement that could build on the *epIAs* previously conducted on SDP and rinderpest, for example. Similar arrangements are required across the revamped CRP portfolio of the CGIAR Strategy and Results Framework 2016-2030 to address the absence of *ex-post* impact assessments of the CGIAR's livestock-related research on society (poverty) and the environment.

Table 6. Gaps in impact assessment / Centers & CRPs concerned.

Research domain field	Centers concerned	CRPs concerned
(1) livestock – crop/feed nexus (animal and plant genetic resources, fish as feed)	ILRI, ICARDA, ICRISAT, IRRI, CIMMYT, CIAT, IITA, CIP, ICRAF, IFPRI, World Fish, Bioversity	All AGRI-Food CRPs; Policies, Institutions and Markets CRP
(2) livestock – animal and human health	ILRI, IFPRI	Livestock AGRI-Food CRP; Nutrition and Health CRP; Policies, Institutions and Markets CRP
(3) livestock commodities (value chains, food security, human nutrition)	ILRI, ICARDA, IFPRI	Livestock AGRI-Food CRP; Policies, Institutions and Markets CRP; Nutrition and Health CRP
(4) livestock and the society (economy, poverty, gender, policy/institutions)	ILRI, ICARDA, CIAT, IITA, IFPRI	Livestock AGRI-Food CRP; Policies, Institutions and Markets CRP
(5) livestock and the environment (bio-physical natural resources, range, climate)	ILRI, ICARDA, CIAT, IITA, IFPRI, World Fish, Bioversity	Livestock AGRI-Food CRP; Fish AGRI-Food CRP; Climate Change CRP; Water, Land and Ecosystems CRP; Policies, Institutions and Markets CRP

The recommendation of the 2014 *White Paper on the Strategic Review of Livestock in the CGIAR* for the development of a CG-Consortium-wide livestock research framework is supported by this study as a suitable platform for improved attention of the CGIAR system as a whole to the livestock sector in its contribution to the *UN Sustainable Development Goals (SDGs)*. The prioritization of the domain areas listed in Table 6 might be guiding this framework. Table 6 is an attempt to group Centers and CRPs concerned in those livestock-

related domain fields where gaps in impact assessment might be addressed by a CG-Consortium-wide livestock research framework, presumably best commissioned by ISPC.

As noted earlier, an important research component that emerges from this review is the need to couch the advances that have been identified on issues of measuring the benefits and effects of livestock-related interventions into an impact assessment framework (**Recommendation 1: incorporate methodological advances in *epIA***). This is particularly crucial in an environment in which donors increasingly want (and need) to quantify the returns to investment and to help in priority setting for future investments.

While many of the studies reviewed provide important policy lessons on issues of *inter alia* learning, adoption, and training, they fail to translate these findings into *measurable* impacts that address returns to donor investments. This does not necessarily require that all research fall into the exclusive use of only economic surplus models, as many types of livestock domains are considerably more nuanced in their impacts and benefits. What it does require, however, is a process of documentation in medium- and large-sized investments in livestock that allows the measurement of a range of benefits at farm, sector, value chain, and/or national levels that can be justified rigorously and weighed against the costs of donor investment. This process of documentation is often lacking. The integration of research across Centers in multi-year CRPs of the reformed CGIAR System could provide an opportunity to develop such a process of implementing and conducting *ex-post* impact assessment, but needs to be mainstreamed and emphasized at the highest levels in the CGIAR (**Recommendation 2: integrate livestock-related research across Centers and CRPs in a CGIAR Consortium-wide framework**).

This represents both a challenge and an opportunity for the CGIAR in its livestock-based portfolio. On the one hand, mainstreaming impact assessment into a diversity of livestock domains will require a significant upgrading of the profile and process of impact assessment by Centers and CRPs addressing livestock-related issues. Despite operating in an environment of constrained budgets, this will necessitate that both Centers and donors recognize the need to prioritize investments in personnel and world-class research skills to achieve this. On the other hand, the benefits of such investments are potentially large; and the establishment of a consortium-wide process of impact documentation will facilitate the justification of targeted research themes.

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Appendices

Appendix 1. Terms-of-Reference

Scoping study to evaluate the extent and quality of ex post impact assessment activity on livestock related research in the CGIAR to-date

Over the years there have been many ex post IA studies that have sought to document the impacts of agricultural research in the CGIAR, although the vast majority of these have focused on crop germplasm improvement, i.e., adoption and impact of improved crop varieties. As such there remain serious gaps in the extent to which impact assessment of other components of the CGIAR portfolio have been conducted. To fill this gap, one of the activities of the SPIA-coordinated SIAC program targets assessments of 'under-evaluated areas of CGIAR research'. The list of under-evaluated areas of CGIAR research includes irrigation and water management, livestock, agro-forestry, policy and social sciences, biodiversity and natural research management.

As a first step in a series of activities intended to increase the inventory of credible ex post IAs of under-evaluated CGIAR research, SPIA is commissioning desk studies to review the IA work to-date in each of these areas. A review of the impact of CGIAR research on irrigation and water management has just been completed (Merrey, 2014) and SPIA is now turning its attention to livestock research.

Livestock related research, which encompasses a fairly broad area of CGIAR research activities (animal genetic resource conservation and use, animal health, crop-livestock interactions, livestock feed management, livestock/environment/climate change, livestock value chains, livestock policy) is generally considered to be under-evaluated. A significant part of the CGIAR's livestock related research has historically been conducted or coordinated by ILRI and its predecessors ILCA and ILRAD, although in more recent years other Centers (IFPRI, ICRISAT, ICARDA, IITA, CIAT and World Agroforestry) and CRPs have invested in specific aspects of livestock research. Although precise numbers are difficult to come by, it is likely that the CGIAR has to-date invested some US $500 million or more in livestock-related research since the late 1970s (when ILCA and ILRAD joined the CGIAR). Despite this sizeable investment, there appears to have been relatively few published studies measuring and documenting the impact of this investment ex post. But this warrants closer examination, and for the studies that have been done, a critical review of the methods and data used and the findings would be a good first step in evaluating the potential for commissioning further IA studies.

A key objective of the desk study would be to identify the strengths and limitations of the existing livestock related research impact assessments (in terms of scale effects, rigor of causal relationships, or how close the impact indicators of the studies correspond to the System-Level Outcomes of the reformed CGIAR system). The desk study would also seek to identify the major constraints and limitations in terms of methods, data availability, resources, etc., which would in turn highlight potential for new work. For example, new initiatives may emphasize targeting intermediate impacts, e.g. estimating the extent of influence of ILRI's research on key livestock policies, or simply adoption of research outputs, rather than ultimate, CGIAR system-level outcomes and impacts. But it may also identify some areas of livestock research which have generated technologies or policies that have been widely adopted but as yet undocumented, but have good potential for measurement.

This initial background review will lay the groundwork for a subsequent scoping study which would assess the potential for utilizing state of the art approaches and possibly new data for launching a series of impact assessments of specific improved management related interventions or policy actions deriving from CGIAR research on livestock, irrigation and water management and other presumed under-evaluated areas. Ultimately, this and other critical reviews of past studies and

scoping study reports will form the basis for the SIAC Project Steering Committee recommending to the Fund Council Committee on Evaluation and Impact Assessment some specific areas for further impact assessment work under the SIAC program that has good potential for generating large scale, long term economic, social and environmental impacts from under-evaluated CGIAR research.

Specific objectives of the background review

The desk study would seek to provide:

1. An estimate of the total investment in livestock related research and related activities within the CGIAR since about 1990.
2. A review of what the CGIAR has done in assessing the economic, social and environmental impacts of CG research in the area of livestock management. The review should make critical judgments about the credibility/rigor and scale of those studies relative to the total amount of investment. This should include identification of gaps (i.e., research 'successes' that don't feature in the impact assessment literature) and weaknesses in the reviewed studies, some of the promising methods and approaches used to-date, and key challenges in assessing large scale, long term impacts of CGIAR research in this area.
3. A summary of the estimated economic, social and environmental impacts (or influence) documented by the IA studies deemed to be reasonably credible, whether in quantitative and qualitative terms.
4. Based on survey or even anecdotal evidence, identification of management interventions or policy actions deriving from specific lines of CGIAR livestock related research that appear to warrant serious attention for future adoption and impact assessment studies.

Modus operandi

The desk study will be conducted by a two-person team working together to produce a report that addresses the objectives of the review. The lead consultant, a person with considerable knowledge of and experience with livestock research evaluation inside and outside the CGIAR, will have primary responsibility for overseeing the study and submitting the report as per the designated timeline. The time commitment here is expected to be 15 days. The second consultant, a person with expertise in ex post impact assessment in the context of livestock R & D, will be responsible for reviewing the set of IA studies submitted by the Centers/CRPs to assess the quality and credibility of the claims of those studies. The time commitment here is expected to be 10 days.

Some key reference material would be provided by the ISPC Secretariat, although considerable interactions with relevant CRPs and CGIAR Centers, e.g., ILRI, IFPRI, ICRISAT, ICARDA, CIAT, IITA, World Agroforestry and other relevant individuals would be required by the consultants. The SPIA Secretariat will facilitate initial contact with these institutions. The review is expected to take place between April and June 2015, with a draft final report submitted to SPIA by end June 2015. No travel is envisaged under these terms of reference. The consultants will report to the SPIA Secretariat in Rome (Timothy Kelley). SPIA members/Secretariat will provide feedback on an outline report and the draft final report.

Peer-review: The draft final report should be sufficiently developed to be ready for peer-review by two external reviewers (in addition to SPIA's own comments on it). The lead consultant should outline how she/he has addressed the comments made by the peer-reviewer when submitting the revised final report.

Output: The outputs will include

1. An annotated outline of the report in early May 2015
2. A well-developed draft final report by end of June 2015
3. A final report reflecting feedback from reviewers within two weeks of receiving comments from SPIA.

Appendix 2. SPIA external review and quality rating mechanism

SPIA external review and quality scoring mechanism to be applied to impact assessments (as of February 2014)

1) Clear presentation of the assessed research and resulting innovation (A Necessary Condition)
The study, either internally or with supplemental information, must adequately describe how the Center's or CRP's activities have contributed to specific improvements in the relevant innovation/policy recommendations and, if possible, what the costs were for the Center/CRP, and its partners.

2) Transparent and reasonable assumptions
Are the major assumptions regarding the assessment methodology (in all components of the analysis) transparent and reasonable, i.e., adequately justified?

3) Impact pathway
Are the intermediate steps between research output and impact carefully described? Does it seem plausible /reasonable? i.e., adequately justified? Are confounding factors carefully considered?

4) Impact claim
Is there a good (qualitative, or quantitative where possible) description of the relevant direct and indirect outcomes from the research project?

5) Identification strategy / appropriate counterfactual
Is the causal identification strategy clearly defined and is it defensible/justified for the case at hand? How is self-selection into treatment handled? Does this approach require assumptions that are not likely to be met? Alternatively, has the appropriate counterfactual been established and justified adequately? For the latter, does the counterfactual appear to represent a plausible scenario (including other potential sources of technical and policy change) in the absence of the assessed research outputs?

6) Reliable and representative data on adoption
a) Are the methods used to estimate adoption clearly described? Sample frame clear?
b) Do the methods for eliciting adoption information appear to follow 'good practice'? Are all sources of bias considered?

7) Reliable and representative data on yields, incomes, other outcomes and benefit-cost analyses
a) Are the methods used to estimate productivity gains, unit cost reductions and other outcomes described clearly?
b) Is the description of the methods for assessing outcomes sufficiently detailed to allow someone to replicate the study? Are there alternative sources for such estimates that have not been considered but that would represent a more rigorous and/or cost-effective approach?

8) Sensitivity analysis
Has there been suitable sensitivity analysis to assess the robustness of the conclusions to changes in the underlying assumptions/parameters? Are lower-bound estimates provided (conservative scenario)?

9) Sound attribution of benefits to research and, if relevant, attribution to specific institutions
a) If the study attempts to attribute the benefits of adoption of the innovation to research, is it clearly described and justified, i.e., are potential mitigating factors sufficiently addressed?
b) If the study attempts to attribute the benefits of adoption of the innovation to the particular Center or CRP, is the method for doing so clearly described and adequately justified, i.e., are potential mitigating factors sufficiently addressed?

10) Extrapolation
Does the study make reasonable or plausible extrapolations or generalizations to a wider target group outside the sample frame?

11) Qualifiers
a) Are the obvious limitations of the study clearly explained and/or contextualized?
b) For quasi-experimental and experimental studies, have alternate treatment effects been considered and results discussed in annexures? Have authors provided a clear rationale for choice of methods?

Appendix 3. Summary evaluations of ex-post impact assessment studies on CGIAR livestock research

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
ILRI					
1. Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (project period: 15 August 2007 to 31 December 2009)	USAID 2009	Poultry (animal disease)	Project document summarizes the results of the Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (ORIHPIA) project. The aim of the project was to develop and evaluate the impacts and feasibility of different control strategies for HPAI, taking into account their various economic and socio-cultural dimensions. Risk factors for and transmission dynamics of disease were also assessed. Part of the project document highlights the cost-effectiveness of HPAI mass vaccination (section 3.3), based on results from the 16 operational districts. This is the focus of this review. Results from this part of the analysis show that mass vaccination is not cost-effective, with BCRs depending on program ranging from 0.16-0.44.	The analysis contains thorough field level data for different control campaigns on the costs associated with disease control interventions. Study results are grounded in standard epidemiological techniques. Analysis raises important issues concerning cost-sharing and institutional mechanisms.	The study does not fully disaggregate the potential benefits associated from disease control, focusing only on the avoided losses of birds valued at market prices. Downstream impacts were not calculated due to a lack of data. Dynamic economic impacts (changes in prices, welfare, etc.) were not computed. Cost-effectiveness at a campaign level not calculated. Sensitivity or scenario analysis of different epidemiological parameters not conducted. Economic analysis relatively rudimentary – cost-effectiveness approach follows standard techniques but little in the way of economic sophistication or innovation.
2. Kenyan Dairy Policy Change:	Kaitibie et al. 2010	Dairy (food safety/marketing)	The analysis looks at the impact of policy changes associated with	The paper uses standard impact assessment techniques	The attribution of policy change in economic terms is

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
Influence Pathways and Economic Impacts			liberalizing informal milk marketing in Kenya. The analysis uses of economic displacement model to assess the distributional impact of policy reforms, and to assess them against a counterfactual of policy delay. Model results show a NPV of US$230 million over 1997-2039 and an IRR of 55%.	based on economic welfare theory to assess the distributional benefits to different actors in the milk value chain, including milk vendors and input suppliers. BCRs and IRRs of the intervention are provided, with counterfactual scenarios also considered. The data used to calibrate the model is based largely on robust project data from the Smallholder Dairy Project. The paper further makes a strong attempt to link economic benefits to timelines of policy change, which is an important methodological innovation.	challenging to measure. Before vs. after policy change data are somewhat problematic to compare given other potentially confounding factors that could influence these. Downstream impacts not considered. More sensitivity analysis could have been conducted.
3. Genetically improved dual-purpose cowpea. Assessment of adoption and impact in the dry savannah of West Africa	Kristjanson *et al*. 2008	Cattle and adoption of dual-purpose cowpea	The paper examines the impact of dual-purpose cowpea adoption on livelihoods in mixed cropping systems in West Africa. The paper combines participatory qualitative approaches with a crop model, spatial GIS modeling, and an economic surplus model to address specific spatial and distributional impacts of adoption. Yield changes from improved varieties were simulated from the crop model based on variety	The analysis combines standard impact assessment tools (economic surplus models) with a host of qualitative and quantitative tools to parameterize and calibrate the impact associated with the intervention. Results are disaggregated by production zone and by year, with sensitivity analysis conducted on different assumptions of	The analysis focuses only on sector-level, partial-equilibrium impacts of cowpea fodder and grain and does not consider other impacts in the livestock sector or the value chain and could underestimate benefits and/or costs. Sensitivity analysis could be more thorough and consider probability distributions of uncertain parameters. Distributional

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			production and locational attributes and spatially disaggregated. A household survey was used to determine and predict adoption rates and their trajectories over time. These inputs were then fed into an economic surplus model to evaluate the net economic benefits from adoption. Model results indicated a 20-year increase in economic surplus of US$1.263 billion, a NPV of US$606.4 million, a benefit cost-ratio of 63.2, and an IRR of 71%	potential yield improvements. Paper is very well written and organized.	impacts only disaggregated based on macro socio-economic domains, not on household typologies within domains.
4. An expost economic assessment of the intervention against highly pathogenic avian influenza in Nigeria	Fadiga et al. 2014	Poultry (animal disease)	The analysis examined the *ex-post* impact of control options associated with avian influenza in Nigeria. The model uses a stochastic risk model to parameterize counterfactual scenarios of disease evolution in the absence of control under different risk parameter estimates. Model results show an average net benefit of HPAI control versus a situation of endemic, high mortality HPAI of US$27.22 million and a BCR of 1.75. BCRs are positive for outbreaks larger than the 50% percentile. The intervention was not financially	The analysis combines epidemiological modeling with an economic analysis to develop impact measures that are grounded in the technical dimensions of the intervention. Counterfactual scenarios based on standard epidemiological modeling techniques are run to look at different scenarios of impact based of different assumptions of risk.	The analysis only reports impact assessment metrics for the endemic, high-mortality scenario and does not show any results for the other possible scenarios of disease evolution (burn-out, high and low mortality; endemic, low mortality). The probability of the different scenarios arising was not considered, so the likelihood of the endemic, high-mortality case is not clear. The economic modeling platform was relatively simple, only looking at direct costs and a simple multiplier, rather

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			viable in cases where HPAI would burn out naturally.		than using a more dynamic, price-responsive economic model.
5. An *Ex-Post* Economic Impact Assessment of Planted Forages in West Africa	Elbasha et al. 1999	Cattle/dairy (technological intervention on fodder banks)	The paper examined the impact of establishing fodder banks by agropastoralists as a means of supplementing feed resources and improving animal nutrition during the dry season. Economic surplus models for milk, meat, and different feedgrains and their associated residues were developed to establish the impact of fodder bank adoption. Data was collected from a survey on fodder banks in a number of West African countries to assess the magnitude of adoption. Price data before and after the intervention was also obtained from the survey. Benefits were computed in terms of improvements in milk yields, animal productivity and changes in herd dynamics, crop and residue yields, and fertilizer saved. Costs were computed based on research costs and fodder bank establishment costs. The results were computed over a 20-year period (1977-1997) and indicated baseline net PV of benefits of US$11.8 million, a BCR of 3.3, and	The analysis combines standard impact assessment tools (economic surplus models) applied to different aspects of the livestock system in question (animals, milk, fodder). Results are disaggregated by country and by year, with sensitivity analysis conducted on different assumptions of potential adoption rates. Herd models used to calibrate adoption impacts.	Sensitivity analysis could be more thorough and consider probability distributions of uncertain parameters. Distributional impacts only disaggregated based on country level domains, not on household typologies within domains. Interactions between different livestock markets not considered.

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			an IRR of 38%. Sensitivity analysis was conducted by increasing and decreasing the number of adopters by 20%, with IRRs ranging from 26%-53%. Projections to 2014 under low and high adoption rates indicated BCRs of interventions of over 7 and net PV of benefits ranging from US$65 million to US$81 million.		
6. An assessment of the *ex-post* socio-economic impacts of global rinderpest eradication: Methodological issues and applications to rinderpest control programs in Chad and India	Rich *et al.* 2014	Cattle (animal disease)	The paper examined the *ex-post* impact of rinderpest eradication in two case study sites – Chad and India. A methodological framework to examine the various dimensions of impacts from the producer level through the value chain to macroeconomic and environmental impacts was provided. A simulation model of cattle population growth was calibrated to baseline and counterfactual scenarios of rinderpest-associated mortality; this was linked to sector, meso-, and macro level economic models. Results from Chad indicated a baseline BCR associated with eradication of 4.02, with different mortality assumptions giving a range of -5.83 to 47.15. In India, the analysis distinguished between	The analysis provides a comprehensive approach to *ex-post* impact assessment in the livestock sector, focusing on micro-level impact through sector-level analysis; meso- or value-chain impacts by using a social accounting matrix; and macro effects using a CGE model. In doing such an integrated, multi-dimensional analysis, the approach moved beyond standard economic welfare approaches used by SPIA for impact assessment to try to capture the complexities in the livestock sector. The use of DynMod, a population model of herd dynamics, showed a means to conduct dynamic	The methodological approach advanced in the paper was not fully operationalized due to data constraints. Issues of environmental impacts and externalities were not analyzed. While focus was on global eradication, the analysis only looked at specific case studies, with regional and cross-border impacts not considered.

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			different control campaigns, finding strong (BCR >64) benefits to rinderpest control during the 1990s given strong market access benefits associated with disease control.	counterfactual assessments that are important in biological systems (livestock, fish) and take into account biological adjustments associated with policy change.	
7. Broad bed maker technology package innovations in Ethiopian farming systems: An *ex-post* impact assessment	Rutherford et al. 2008	Technological adoption (plough technology)	Updates analysis of Rutherford et al. 2001 to extend *ex-post* analysis to 2008 (see (8) below for a detailed discussion of analysis).	The model uses standard impact assessment tools combining primary adoption data with an economic surplus model to calculate NPV, IRR, and BCR.	Financial measures are rather strange – BCR reported as 3.3, but NPV is negative and IRR just 0.1. Credibility of results highly suspect.
8. The role of the broadbed maker plough in Ethiopian farming systems: An *ex-post* impact assessment study	Rutherford et al. 2001	Technological adoption (plough technology)	The paper examines the *ex-post* impact of the adoption of the broadbed maker plough in livestock systems in Ethiopia as a means of improving crop yields. Primary surveys were used to examine the extent of technology update and the impacts the technology had on crop yields, crop mix, and production costs. Economic surplus results revealed significant costs that strongly outweighed the benefits of technology, with a BCR of 0.01 and a NPV of -$12.6 million. Positive benefits would require a significantly higher adoption rate	The model uses standard impact assessment tools combining primary adoption data with an economic surplus model to calculate NPV, IRR, and BCR.	Results strongly show negative impacts associated with technology in terms of high costs. Sensitivity analysis could be more thorough and consider probability distributions of uncertain parameters.

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			(over 4%) over a longer-time horizon.		
9. Management of internal parasites in goats in the Philippines	Montes et al. 2008	Technological adoption of best practices for parasite management (goats)	The paper examines the impact of various projects associated with the implementation and adoption of pest management practices for goat production in the Philippines. The paper consists of a benefit-cost analysis in which the costs of different research programs were measured against the benefits from higher adoption and reduced production costs from new management techniques. The latter was fed into an economic surplus model to evaluate the net economic benefits from adoption, with sensitivity analysis applied to different rates of adoption and investment, and on higher productivity impacts. Model results indicated NPV of benefits of A$66 million from 2007 to 2030, an IRR of 25%, and a BCR of 10.4. Sensitivity analyses of more conservative assumptions revealed positive impacts as well (BCR of 5.6, IRR of 19%)	The analysis combines standard impact assessment tools (economic surplus models) to the goat production system, with productivity shocks calibrated from primary data.	Sensitivity analysis could be more thorough and consider probability distributions of uncertain parameters. Distributional impacts only disaggregated based on the basis of two regions, not on household typologies within domains. Sampling basis of impacts not as thorough as in other studies. Indirect/second-round impacts not computed and may understate impacts.
ICARDA					
10. Promoting the adoption of natural resource	Alary, V., Nefzaoui, A.,	Crop/livestock systems	The model examines the adoption of the spineless cactus in alley cropping production system in	The model is extremely complex and interesting through its integration of	Does not report IA metrics (IRR, BCR, NPV), although these are found in (12) using

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
management technology in arid and semi-arid areas: Modelling the impact of spineless cactus in alley cropping in Central Tunisia. *Agricultural systems*, *94*(2), 573-585	& Jemaa, M. B. (2007).		Tunisia, an integrated crop/livestock system for drought-prone areas. The system provides a source of perennial crops, feed, and biomass for adopters. A bio-economic model was used that integrates (1) a crop/livestock production model, (2) a farm-level consumption and resource allocation model, (3) an aggregation module that integrates (1) and (2) to look at production and resource tradeoffs, and (4) a recursive optimization module that looks at household behavior, includes aspects of risk preferences. The model is based on a series of quantitative surveys on adoption as well as a survey on the willingness-to-pay for technology based on different subsidy levels. The model further distinguishes between different farm and pastoralist typologies in its analysis. Model results show different adoption rates among different farm groups for different scenarios associated with varied levels of public support to farmers for the technology, with higher	different aspects of crop/livestock systems at both production and household levels. The recursive optimization approach further allows for adjustments in stakeholder behavior over time. Model disaggregates households according to farm typologies, which allows teasing out of equity and distributional issues. Issues of risk addressed through use of Target MOTAD framework in optimization. Provides useful complement to economic surplus methods.	the same modeling approach. Model is somewhat opaque in description, with some parts a bit of a "black box", though overall framework of modules relatively clear. Impacts not analyzed at sector-level as in an economic surplus framework, so benefits are likely understated. Price impacts or adjustments not directly modeled. Sustainability of public support of long-term not discussed.

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			levels of public support associated with higher uptake.		
11. ICARDA. *Ex-post* Impact Assessment of Natural Resource Management Technologies in Crop–Livestock Systems in. *International Research on Natural Resource Management: Advances in Impact Assessment*, 169.	Shideed, K., Alary, V., Laamari, A., NEFZAOUI AND, A., & El Mourid, M. (2007).	Crop/livestock systems	The paper provides a summary of crop-livestock interventions conducted in Tunisia and Morocco, with the former largely summarized in (10) and (12). The focus of the paper empirically is the computation of FIRR (Financial IRRs) and EIRR (Economic, or Social IRRs) that take into account social returns. The Morocco case applies the SCUAF model "Soil Change Under Agro-Forestry" Model to examine the impact of adoption of the Atriplex cropping system, as a means of reducing soil erosion and promoting crop-livestock integration. The SCUAF model is primarily a biophysical model with economic parameters derived from a farm survey and econometric estimation of a production function and other farm productivity parameters. Model results estimate the FIRR within the community at 50% and EIRR at 25%, while national levels effects are nearly double (90% and 48%, respectively). Positive environmental impacts of interventions also revealed that	As in (10) and (12) for Tunisia; for Morocco, model demonstrates an integration of biophysical models with economic model. Analysis of potential positive environmental impacts of the intervention extremely interesting.	As in (10) and (12); issue of public intervention strongly made but issues of sustainability and exit strategies not thoroughly addressed. Morocco case study model not as sophisticated as Tunisia, with stakeholder decision making not endogenized. Price impacts not given.

Case (citations on Google Scholar as of 08.06.2015)	Reference	Specific livestock sector or issue analyzed	Brief Summary	Strengths	Weaknesses
			are larger than the level of subsidy provided.		
12. *Ex-post* impact assessment of NRM research in the arid and semiarid areas: the case of the Mashreq/Maghreb project experience. Tunisia case study: Spineless cactus in alley cropping (0)	Alary et al. (date?)	Crop/livestock systems	This paper elaborates more some of the data and financial metrics associated with the model used in (10). The authors examine the profitability of the spineless cactus in alley cropping system under various scenarios of productivity, subsidy, and end markets, with BCRs ranging from 1.72 (lower production levels, no pad market) to 23.10; IRRs of 6-57%, and NPVs of -75,000 to 1.4 million Tunisian Dinars.	As above in (10), with more details on specific technical aspects of the intervention. Good linking of adoption behavior to impact.	Analysis is somewhat disorganized and hard to follow in comparison to (10), although provides details on sources on some of the data parameters used in the journal. Confusing inconsistency in part of investment analysis with negative NPV but positive (>1) BCR in one instance.

Appendix 4. Characterization of ex-post livestock impact assessments

Case	Reference	Type of innovation	Type of IA and methodological theme	Data used	Credibility	Notes
ILRI						
1. Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (project period: 15 August 2007 to 31 December 2009)	USAID 2009	Policy	Qualitative and quantitative, benefit-cost analysis, cost-effectiveness	Household survey data, secondary data	Moderate; not peer reviewed but techniques used relatively standard and non-controversial. National scale, not IPG but lessons relevant at global level.	
2. Kenyan Dairy Policy Change: Influence Pathways and Economic Impacts	Kaitibie et al. 2010	Policy	Quantitative, economic surplus	Household survey data, secondary data	High; referred publication in top-tier development journal. National scale but potential IPG given methodological contributions.	
3. Genetically improved dual-purpose cowpea. Assessment of adoption and impact in the dry savannah of West Africa	Kristjanson et al. 2008	Technology	Quantitative, economic surplus, crop model, GIS analysis	Household survey data, GIS, secondary data	High; not peer reviewed but well organized analysis. Regional scale, not IPG, but makes methodological contributions on mixed methods. Solid IA based on standard methods.	

Case	Reference	Type of innovation	Type of IA and methodological theme	Data used	Credibility	Notes
4. An ex-post economic assessment of the intervention against highly pathogenic avian influenza in Nigeria	Fadiga et al. 2014	Policy	Quantitative, epidemiological simulation model, benefit-cost analysis	Secondary data	Moderate; peer reviewed, although not in top-ranked journal. National scale, not IPG, but makes some methodological contributions.	
5. An Ex-Post Economic Impact Assessment of Planted Forages in West Africa	Elbasha et al. 1999	Technology	Quantitative, economic surplus, herd dynamic models	Household survey data, secondary data	Moderately high; not peer reviewed but well organized analysis. Regional scale, not IPG, but makes methodological contributions on mixed methods. Solid IA study with standard methods.	
6. An assessment of the ex-post socio-economic impacts of global rinderpest eradication: Methodological issues and applications to rinderpest control programs in Chad and India	Rich et al. 2014	Policy	Quantitative, simulation approaches, herd dynamic models, social accounting matrices	Secondary data	High; referred publication in top-tier development journal. National scale but potential IPG given methodological contributions.	
7. Broad bed maker technology package innovations in Ethiopian farming systems: An ex-post impact assessment	Rutherford et al. 2008	Technology	Quantitative, economic surplus model	Primary and secondary data	Low; not peer reviewed and analysis not terribly complex. IA metrics suspect.	

Case	Reference	Type of innovation	Type of IA and methodological theme	Data used	Credibility	Notes
8. The role of the broadbed maker plough in Ethiopian farming systems: An ex-post impact assessment study	Rutherford et al. 2001	Technology	Quantitative, economic surplus model	Primary and secondary data	Low; not peer reviewed and analysis not terribly complex.	
9. Management of internal parasites in goats in the Philippines	Montes et al. 2008	Technology	Quantitative, economic surplus model	Primary data on crop budgets, secondary data on research expenditures	Moderate; not peer reviewed and analysis not terribly complex, but highlights a solid epIA.	
ICARDA						
10. Promoting the adoption of natural resource management technology in arid and semi-arid areas: Modelling the impact of spineless cactus in alley cropping in Central Tunisia. *Agricultural systems*, 94(2), 573-585	Alary, V., Nefzaoui, A., & Jemaa, M. B. (2007).	Crop/livestock system	Quantitative, bio-economic model	Multiple primary datasets, secondary data	High; peer reviewed with a number of citations. Model is quite complex; intuition for mechanics could be enhanced, but integration across livestock domains interesting.	
11. ICARDA. Ex-post Impact Assessment of Natural Resource Management Technologies in Crop–Livestock Systems in. *International Research on Natural Resource Management: Advances in Impact Assessment, 169.*	Shideed, K., Alary, V., Laamari, A., NEFZAOUI AND, A., & El Mourid, M. (2007).	Crop/livestock system	Quantitative, bio-economic model	Multiple primary datasets, secondary data	Moderate; summarizes work of (10) and (12), with new information provided on additional intervention in Morocco.	

Case	Reference	Type of innovation	Type of IA and methodological theme	Data used	Credibility	Notes
12. Ex-post impact assessment of NRM research in the arid and semiarid areas: the case of them Mashreq/Maghreb project experience. Tunisia case study: Spineless cactus in alley cropping (0)	Alary et al. (date?)	Crop/livestock system	Quantitative, bio-economic model	Multiple primary datasets, secondary data	Moderate – much of the main results summarized in (10), though impact assessment measures reported here. Analysis is somewhat disorganized and could be streamlined.	

Appendix 5. Grouping of selected reports thematically

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
1. Ex-post impact assessments that specifically highlight returns to investment	*a. Standard epIAs using economic surplus techniques (included as epIA's in Appendices 3 and 4)*	Kaitibie, S., A. Omore, K. Rich, and P. Kristjanson, (2010). Kenyan Dairy Policy Change: Influence Pathways and Economic Impacts. Elsevier, World Development, Vol. 38, No. 10, pp. 1494-1505 Kristjanson, P., Tarawali, S.A., Okike, I., Singh, B.B., Thornton, P.K., Manyong, V.M., Kruska, R.L., Hoogenboom, G. (2002). Genetically improved dual-purpose cowpea. Assessment of adoption and impact in the dry savannah of West Africa. LRI Impact Assessment Series 9. Elbasha, E., Thornton, P.K., Tarawali, G. (1999) An *Ex-Post* Economic Impact Assessment of Planted Forages in West Africa, ILRI Impact Assessment Series Montes, N.D.; Zapata, Jr N.R.; Alo, A.M.P.; Mullen, J.D. (2008). Management of internal parasites in goats in the Philippines. ACIAR Impact Assessment Series Report 57 Rutherford, A. S., Odero, A. N., & Kruska, R. L. (2001). *The role of the broadbed maker plough in Ethiopian farming systems: An ex post impact assessment study* (Vol. 7). ILRI Rutherford, A. S. (2008). *Broad bed maker technology package innovations in Ethiopian farming systems: An ex post impact assessment*. ILRI	Papers in this sub-category apply economic surplus methods to calculate returns to investment, based on various means to calculate economic benefits from primary and secondary data. The most comprehensive studies develop typologies of impact from livelihoods domains and integrate spatial methods to highlight returns. All papers address returns to investments through the calculation of investment metrics such as BCRs and IRRs.
	b. CBA or simulation-type CBA models with epIA impact measures provided (NPVs, IRRs, BCRs) (included as	Alary,V, A. Nefzaoui, and M. Ben Jemaa, (2007). Promoting the adoption of natural resource management technology in arid and semi-arid areas: Modeling the impact of spineless cactus in alley cropping in Central Tunisia. Agricultural Systems 94 (2007) 573–585	Papers in this category are more standard CBA approaches and are not as typically not as comprehensive in computing economic impact beyond the

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
	epIA's in Appendices 3 and 4)	Alary, V., A. Nefzaoui, M. Elmourid, M.M. Ben Jemaa, S.Chouki, H. Ben Salem, M. Elloumi, S. Selmi, and K. Shideed, (s.d.). *Ex-post* impact assessment of NRM research in the arid and semi-arid areas: The case of the Mashreq/Maghreb project experience ; Tunisia Case Study – Spineless Cactus in Alley Cropping. CIRAD-Emvt/ICARDA Tunis, and Laboratoire des Productions Animale et Fourragère, INRAT Tunisie USAID / ILRI, Final Report (2011). Operational Research in Indonesia for More Effective Control of Highly Pathogenic Avian Influenza (project period: 15 August 2007 to 31 December 2009) Fadiga, M.L., Okike, I., Bett, B.(2014). An expost economic assessment of the intervention against highly pathogenic avian influenza in Nigeria Rich, K. M., Roland-Holst, D., & Otte, J. (2014). An assessment of the *ex-post* socio-economic impacts of global rinderpest eradication: Methodological issues and applications to rinderpest control programs in Chad and India. Food Policy, 44, 248-261. Shideed, K., V. Alary, A. Laamari, A. Nefzaoui, and M. El Mourid, (2007). *Ex-post* Impact Assessment of Natural Resource Management Technologies in Crop-Livestock Systems in Dry Areas of Morocco and Tunisia. International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria; Centre International de Recherche Agronomique pour le Developpement (CIRAD)-Emvt/International Centre for Agricultural Research in the Dry Areas (ICARDA), Tunis, Tunisia; Institut National de la Recherche Agronomique (INRA), Settat, Morocco; Laboratoire des Productions Animale et Fourragere, Institut National de la Recherche Agronomique de Tunisie (INRAT), Tunisia	farm level. These papers vary in sophistication from accounting types of CBAs to the application of bio-economic platforms integrated with household models of farming systems. All papers address returns to investments through the calculation of investment metrics such as BCRs and IRRs.
2. Other studies assessing components of ex-post impact	*a. Propensity matching techniques (potential applications to epIA, but not IA's per se)*	Lapar, M.L., N.N. Toan, C. Zou, J. Liu, X. Li, and T. Randolph (2011). An impact evaluation of technology adoption by smallholders in Sichuan, China: the case of sweet potato-pig systems. 55th Annual AARES National Conference, Melbourne, Victoria, February 2011	Papers in this sub-category use quasi-experimental methods to look at impact between targeted and control

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
but not specifying returns to investment		Ahmed, I. (2012). Socio-economic impact of forage development on farm households livelihood in Mieso district, West Hararghe zone, Oromia national regional state. (MSC thesis; Haramaya University) Teufel, N., Nancy Johnson, Dhiraj Singh, (2011). The Adoption and impact of an improved drought - tolerant, dual- purpose groundnut variety in Southern India Liebenehm, S., Hippolyte Affognon, and Hermann Waibel, (2009). Impact assessment of agricultural research in West Africa: an application of the propensity score matching methodology, International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009 Quisumbing, Agnes R., Shalini Roy Jemimah Njuki Kakuly Tanvin Elizabeth Waithanj, (2013). Can Dairy Value Chain Projects Change Gender Norms in Rural Bangladesh? Impacts on Assets, Gender Norms, and Time Use. IFPRI Discussion Paper 01311 Abebe, T. (2011) . The impact of input and output market development intervention of the IPMS Project: The case of Meiso Woreda, Oromiya National Regional State, Ethiopia.MS thesis, Haramaya University Getachew, Y. 2010. Impact assessment of input and output market development interventions of the IPMS Project: The case of Alaba and Dale Woredas, SNNPR, Ethiopia. MSc thesis in Agriculture (Agricultural Economics). 80p. Haramaya (Ethiopia): Haramaya University Ndirangu, L, E. Birol, R. Roy, and Y. Yakhshilikov. (2009). The Role of Poultry in Kenyan Livelihoods and the Ex Ante Impact Assessment of HPAI on Livelihood Outcomes. HPAI Research Brief, No. 11. DFID, IFPRI, ILRI, RVC. Ndirangu, L, E. Birol, R. Roy, and Y. Yakhshilikov. (2011). Assessing the Livelihood Impacts of a Livestock Disease Outbreak - An Alternative Approach. IFPRI Discussion Paper 01081	populations. They vary in their level of sophistication but demonstrate the value of more finely teasing out the attributes associated with impact. These studies are limited from an epIA standpoint in that they do not link benefits to impact i.e. they do not compute the returns and costs associated with obtaining the impacts measured.

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
	b. Experimental methods and RCT's (potential applications to epIA, but not IA's per se)	Bett, B.,T.F. Randolph, P. Irungu, S.O. Nyamwaro, P. Kitala, J. Gathuma, D. Grace, G. Vale, J. Hargrove, and J. McDermott. Field trial of a synthetic tsetse-repellent technology developed for the control of bovine trypanosomosis in Kenya. Preventive Veterinary Medicine, Volume 97, Issues 3–4, 1 December 2010, Pages 220–227. Grace, D., T. Randolph, O. Diall, and P.H. Clausen, (2008) Training farmers in rational drug-use improves their management of cattle trypanosomosis: A cluster-randomised trial in south Mali, Elsevier. Preventive Veterinary Medicine, 83: 83-97 Carter, M.R. and S.A. Janzen, (2012). Coping with drought: Assessing the impacts of livestock insurance in Kenya. Index Insurance Innovation Initiative BASIS Brief 2012-1. Davis, CA: I4 Index Insurance Innovation Initiative. Janzen, S. A. and Carter, M. R. 2013. After the drought: The impact of microinsurance on consumption smoothing and asset protection. http://www.nber.org/papers/w19702 Jensen, N. D., Barrett, C. B. and Mude, A. 2014. Basis risk and the welfare gains from index insurance: Evidence from northern Kenya. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2505764&download=yes Jensen, N. D., Mude, A. and Barrett, C.B. 2014. How basis risk and spatiotemporal adverse selection influence demand for index insurance: Evidence from northern Kenya. http://dx.doi.org/10.2139/ssrn.2475187 Jensen, Nathaniel, Christopher Barrett, and Andrew Mude. 2015. Index Insurance and Cash Transfers: A Comparative Analysis from Northern Kenya. Available at https://drive.google.com/file/d/0Bxuu0YRdPEO2eDdCVXJOaXNwWXc/view	Papers in this sub-category use more rigorous experimental methods to look at impact between targeted and control populations. As with the previous sub-category, these studies are limited from an epIA standpoint in that they do not link benefits to impact i.e. they do not compute the returns and costs associated with obtaining the impacts measured.

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
		Takahashi, K., M. Ikegami, M. Sheahan, C.B. Barrett, (2014). Quasi-experimental evidence on the drivers of index-based livestock insurance demand in southern Ethiopia. Institute of Developing Economies discussion paper 480.	
	c. Adoption and learning impacts (potentially interesting results but not couched in epIA framework)	Bosma, R.H., R. L. Roothaert, P. Asis, J. Saguinhon, L.H. Binh, and V.H. Yen, (2003). Economic and social benefits of new forage technologies in Mindanao, Philippines and Tuyen Quang, Vietnam. CIAT Working Document No. 191. Centro Internacional de Agricultura Tropical, Los Baños, Philippines, 92 pages. Catley, A., O. Suji, and B. Omwansa, (2008). Impact assessment of livestock farmer field schools in Nakuru and Nyandarua Districts, Kenya. A report for the International Livestock Research Institute. Edinburgh, UK: Vetwork. Grace, D., M. Dipeolu, J. Olawoye, E. Ojo, S. Odebode, M. Agbaje, G. Akindana, and T. Randolph, (2012). Evaluating a group-based intervention to improve the safety of meat in Bodija Market, Ibadan, Nigeria. Springer, *Tropical Animal Health and Production* Holmann, F., L. Rivas, P.J. Argel, and E. Pérez, (2004). Impacto de la adopción de pastos Brachiaria: Centroamérica y México. Cali, Colombia, Centro Internacional de Agricultura Tropical (CIAT), 2004. 32 p. (Documento de trabajo no. 197) Holmann, F., P. Argel, and E. Pérez, (2008) Impact from the Adoption of improved Forages in smallholder farms in Central America. . Centro Internacional de Agricultura Tropical (CIAT); International Livestock Research Institute (ILRI). 2008 17 p.(Working Document No, 208) Kang'ethe, E., V. Kimani, D. Grace, G. Mitoko, B. McDermott, J. Ambia, C. Nyongesa, G. Mbugua, W. Ogara, and P. Obutu, (2012). Development and delivery of evidence-based messages to reduce the risk of zoonoses in Nairobi, Kenya. Springer, *Tropical Animal Health and Production*	Papers in this sub-category look at adoption and learning impacts in different livestock domains. As with other studies in this category, they do not capture the returns associated with the impacts and learning effects measured.

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
		Maxwell, T.W., Y. Songly, B. Boratana, L. Peou, and J. Reid, (2002). The social and other impacts of a cattle/crop innovation in Cambodia. Agricultural Systems 107 (2012) 83–91. Nicholson, C.F., P.K. Thornton, L. Mohammed, R.W. Muinga, D.M. Mwamachi, E.H. Elabasha, S.J. Staal, and W. Thorpe, ILRI, Nairobi (Kenya). (1999). Smallholder dairy technology in coastal Kenya. An adoption and impact study. ILRI Impact Assessment Series 5. Peters, D. Nguyen Thi Tinh, Mai Thach Hoan, Nguyen The Yen, Pham Ngoc Thach, and Keith Fuglie, (2005). Rural income generation through improving crop-based pig production systems in Vietnam: Diagnostics, interventions, and dissemination. Agriculture and Human Values 22: 73–85 Roesel, K., and D. Grace (eds). 2015. Food safety and informal markets: animal products in Sub-Saharan Africa. Earthscan from Routledge Roothaert, R.L., B. Le Hoa, Ed Magboo, Vu Hai Yen, J. Saguinhon, (2004). Participatory forage technology development in Southeast Asia. In: A. Yimegnuhal and T. Degefa (eds.), 2005. Participatory Innovation and Research: Lessons for Livestock Development. Proceedings of the 12th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, August 12-14, 2004., vol. 1: Plenary Session. Ethiopian Society of Animal Production, Addis Ababa. pp. 21-30. Stür, W., Phonepaseuth Phengsavanh, F. Gabunada, P. Horne, Truong Tan Khanh, Viengsavanh Phimphachanhvongsod, J. Connell, and F. Holmann, (s.d.). A survey of adoption of improved forages in Southeast Asia (no source) White, D., M. Peters, and P. Horne, (2013). Global impacts from improved tropical forages: A meta-analysis revealing overlooked benefits and costs, evolving values	

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		and new priorities. Tropical Grasslands – Forrajes Tropicales (2013) Volume 1, 12−24. Wünscher, T. R. Schultze-Kraft, M. Peters, and L. Rivas, (2004). Early adoption of the tropical legume *Arachis pintoi* in Huetar Norte, Costa Rica, Expl. Agric. (2004), volume 40, pp. 257–268	
3. Other impact studies not qualifying as epIAs	*a. Other relevant papers for quantitatively examining benefits of livestock interventions (potential applications to epIA, but not IA's per se)*	Lapar, M.L., R. Deka, J. Lindahl, and D. Grace (2014). Quality and safety improvements in informal milk markets and implications for food safety policy. Contributed paper, ASAE 2014. (distributional benefits in terms of VA given, but not pure CBA, nor costs of program costed). Johnson, N., Wambile, A., (2011). The impacts of the Arid Lands Resource Management Project (ALRMPII) on livelihoods and vulnerability in the arid and semi-arid lands of Kenya (other – mix of methods to assess impact on different metrics)	Papers in this category provide some guidance on dimensions of impact but are not epIAs in their own right.
	b. Epidemiological transmission studies (potential inputs to epIA, but not IA's per se)	Ssematimba, A., I. Okike, G. Maina, FAO, G.J. Boender, T.J. Hagenaars, and B. Bett, (forthcoming in: Epidemics Journal). Estimating between-farm transmission rate parameters for Highly Pathogenic Avian Influenza subtype H5N1 epidemics in Bangladesh. Verdugo, C., I. ElMasry, J. Yilma, H. Hannah, C. Jewell, F. Unger, M. Soliman, S. Galal, J. Lubroth, and D. Grace, (forthcoming in: PVM). A Bayesian sensitivity and specificity estimation of the participatory disease surveillance program for highly pathogenic avian influenza in Egypt.	
	c. Outcome mapping (potential applications to epIA, but not IA's per se as quantified aspects missing)	Chotinun, S., S. Rojanasthien, K. Tohtubtiang, and F. Unger, (2014). Application of Outcome Mapping to monitor and evaluate improvement of hygienic practices of small-scale poultry slaughterhouses in northern Thailand. Poster presented at the Ecohealth 2014 conference, Montreal, Canada, 11-15 August 2014.	

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		Chotinun, S., S. Rojanasthien, K. Tohtubtiang, and F. Unger, (2014). Application of Outcome Mapping to monitor and evaluate improvement of hygienic practices of small-scale poultry slaughterhouses in northern Thailand. Poster presented at the Ecohealth Conference, Montreal, Canada, 11-15 August 2014. Gilbert J., D. Grace, F. Unger, M.L. Lapar, R. Assé, K. Tohtubtiang, K. Borin, Y. Guorong, W. Digna, M. Van Hiep, S. Chotinun, M. Tongkorn, D.A. Widiasih, and A. Wyatt, (2014). Outcomes in building capacity and strengthening networks: Ecohealth in Southeast Asia. ILRI Research Brief 16. Nairobi, Kenya Gilbert J., D. Grace, F. Unger, M.L. Lapar, R. Assé, K. Tohtubtiang, K. Borin, Y. Guorong, W. Digna, M. Van Hiep, and A. Wyatt, (2014). Increasing awareness of zoonotic diseases among health workers and rural communities in Southeast Asia. ILRI Research Brief 15. Nairobi, Kenya. Gilbert, J., D. Grace, F. Unger, M.L. Lapar, R. Assé, K. Tohtubtiang, K. Borin, Y. Guorong, W. Digna, M. Van Hiep, S. Chotinun, and A. Wyatt, (2014). Engaging stakeholders to manage emerging zoonotic diseases in Southeast Asia. ILRI Research Brief 14. Nairobi, Kenya. Nyangaga J, K. Roesel, S. Hendrickx, E. Kang'ethe, and D. Daouda. (2012). Safe Food, Fair Food: From capacity building to implementation. Report on the outcome mapping strategy, implementation and monitoring framework. ILRI (International Livestock Research Institute), Nairobi. Nyangaga, J., T. Smutylo, D. Romney, and P. Kristjanson. (2010). Research that matters: Outcome mapping for linking knowledge to poverty-reduction actions. Development in Practice. 20(8): 972 – 984. Tohtubtiang, K., R. Assé, F. Unger, J. Gilbert, and D. Grace, (2014). Intentional stakeholder outreach using Outcome Mapping: Ecosystem approaches to the	

Categories of identified *ex-post* impact assessment studies	Theme sub-categories and description	Selected papers within this theme	Comments on papers
		better management of zoonotic emerging infectious diseases in the Southeast Asia region (EcoZD) project. Presentation at the EcoHealth Conference, Montreal, Canada, 11-15 August 2014.	
	d. Innovation platforms (potential applications to epIA, but not IA's per se as quantified aspects missing)	Cadilhon, J.-J. (2013). A conceptual framework to evaluate the impact of innovation platforms on agrifood value chains development. Paper presented at the 138th seminar of the European Association of Agricultural Economists on pro-poor innovations in food supply chains, Ghent, Belgium 11-13 September 2013. https://cgspace.cgiar.org/bitstream/handle/10568/33710/ImpactAssessment-InnovationPlatforms.pdf?sequence=4 Damtew, E. and A.J. Duncan (2015). Participatory monitoring and evaluation framework to measure Africa RISING innovation platform contributions to project outcomes in the Ethiopian highlands. Nairobi, Kenya: ILRI. Duncan, A.J., E. Le Borgne, F. Maute, and J. Tucker. (2013). Impact of innovation platforms. Innovation Platforms Practice Brief 12. Nairobi, Kenya: ILRI. Pham N.D., J.-J. Casilhon, and B.L.Maass, (2014). Field testing a conceptual framework for innovation platform impact assessment: the case of MilkIT dairy platforms in Tanga region, Tanzania.	
	e. Conceptual frameworks for impact assessment (with specific application to livestock or livestock research)	de Janvry, A., A. Dunstan, and E. Sadoulet, E. 2011. Recent Advances in Impact Analysis Methods for *Ex-post* Impact Assessments of Agricultural Technology: Options for the CGIAR. Report prepared for the workshop: Increasing the rigor of *ex-post* impact assessment of agricultural research: A discussion on estimating treatment effects, organized by the CGIAR Standing Panel on Impact Assessment (SPIA), 2 October, 2010, Berkeley, California, USA. Independent Science and Partnership Council Secretariat: Rome, Italy. Lilja, N., P. Kristjanson, and J. Watts. (2010). Rethinking impact: Understanding the complexity of poverty and change - overview. Development in Practice 20(8):917-932.	

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		Notenbaert A., M. Lannerstad, M. Herrero, S. Fraval, Y. Ran, B. Paul, S. Mugatha, J. Barron, and J. Morris. (2014). A framework for environmental ex-ante impact assessment of livestock value chains. Paper presented at the 6th All Africa Conference of Animal Agriculture, Nairobi, 29 October 2014. Nairobi: International Center for Tropical Agriculture. Nyangaga, J., T. Smutylo, D. Romney, and P. Kristjanson. (2010). Research that matters: Outcome mapping for linking knowledge to poverty-reduction actions. Development in Practice. 20(8): 972 – 984. Njuki, J., P.N. Pali, K. Nyikahadzoi, P. Olaride, and A. Adekunle. (2010). Monitoring and evaluation strategy for the sub-Saharan Africa challenge program. Forum for Agricultural Research in Africa (FARA) Ran, Y., M. Lannerstad, J. Barron, S. Fraval, B. Paul, A. Notenbaert, S. Mugatha, and M. Herrero, (2015). A review of environmental impact assessment frameworks for livestock production systems. Stockholm Environment Institute, Project Report 2015-02. Stockholm, Sweden: Stockholm Environment Institute. Rich, K.M., and Hamza. (2013). Using system dynamics methods for the impact assessment of animal diseases: Applications to Rift Valley fever and food safety interventions in pigs Thornton, P.K. (2006). Ex ante impact assessment and seasonal climate forecasts: status and issues. Climate Research. 33: 55-65.	

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